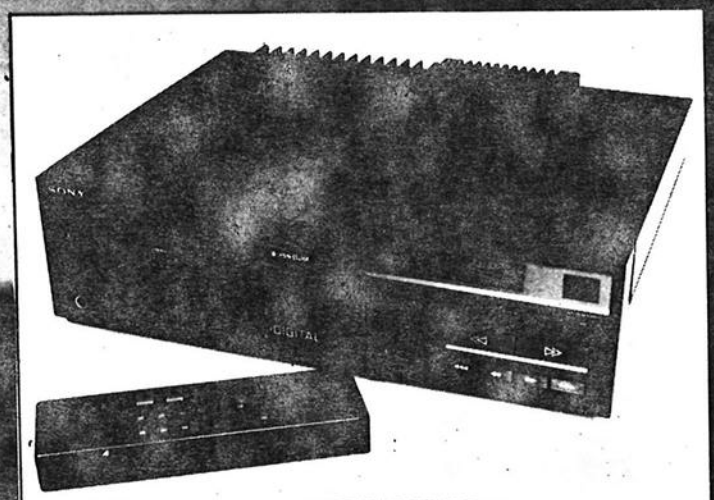
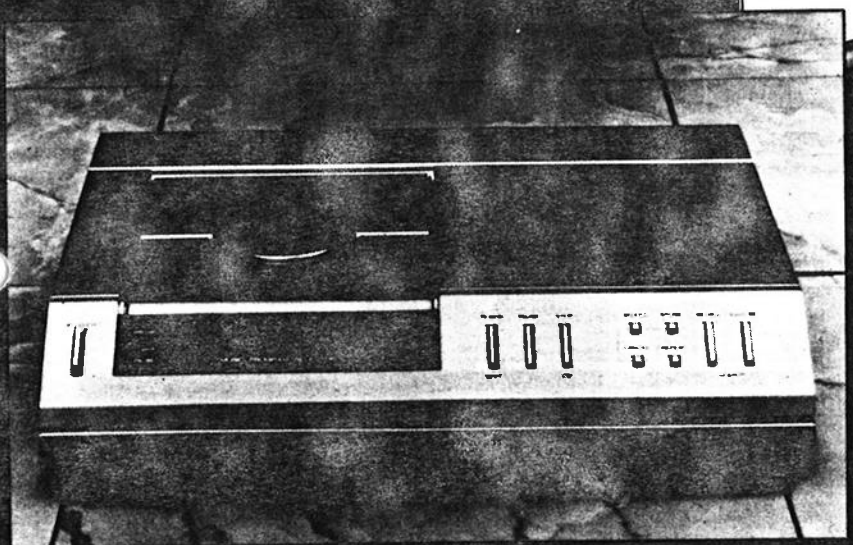
# COMPACT DISC PLAYERS

## Martin Colloms examines the first models available in the UK



Right: Sony's front loader CDP-101



Left: Marantz CD63/Philips CD100

COMPACT DISC is here at last. After many years' wait players should be on public sale very soon after this magazine issue is published. Accompanying the players, initially selling both hi-fi and record dealers, will be a launch inventory of 250-300 record titles, of which a reasonable proportion will be classical. Well in advance of this review I had an opportunity to examine some pre-production CD machines and reported on them in *Hi-Fi Choice: Turntables and Tonearms*. This latest *HFN/RR* report is the first to test the performance of final production models, and also the first to include detailed technical tests using several special test records.

Few readers can have failed to notice that CD is a new record medium using a digital recording-replay process. Possibly the most important aspect is its adoption by over 40 hi-fi manufacturers and also by most of the record industry, and thus it has become a new international audio disc standard. The achievement of such a *de facto* standard is a major strength of CD. Provided that the specification of that standard does not significantly prejudice both the final cost and the performance of the resulting program, the existence of this standard is more valuable than the new medium itself. CD is likely to grow to a point of domination in the record and player industry over the next decade. It is no exaggeration to suggest that 78 is to LP as LP is to CD: no-one with any sense would suggest abandoning the existing LP heritage, but it is quite certain that CD will make an immediate impact on the hi-fi market and thereafter its influence will grow strongly.

I suspect that in view of the understandable reluctance on personal spending in the present economic climate, sales of the new CD players may further depress sales of existing audio equipment. An immediate impact may be expected on high quality analogue LP turntables. With CD players priced initially in the £430-£550 range providing a line level flat response output they are competitive on price alone with conventional £200 turntables when the cost of tonearm

moving-coil cartridge, and possible extra preamp matching requirements, are accounted for.

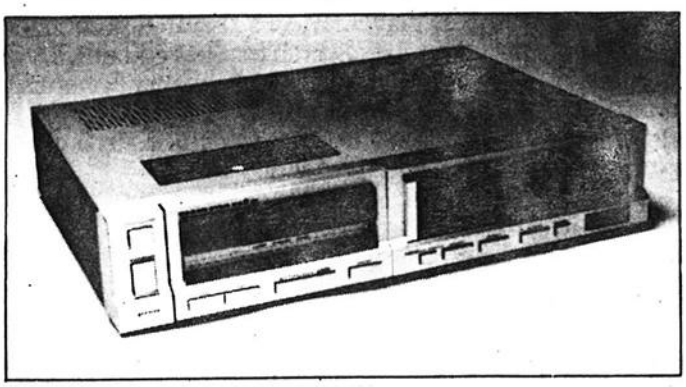
While few prospective purchasers of complete audio systems will seriously consider CD on grounds of cost and available catalogue, those seeking to replace or upgrade part of their system, not just the turntable, will be sorely tempted by the prospect of a CD player. The logic is plain to see. In a typical £1,500 audio system CD would potentially make the largest technical contribution to improved sound, and this by a considerable margin.

Sales of upmarket analogue turntables and related components will thus be under considerable strain in future. The consumer is likely to view them more in the context of competently reproducing existing archive LP material, rather than offering a state-of-the-art audio performance.

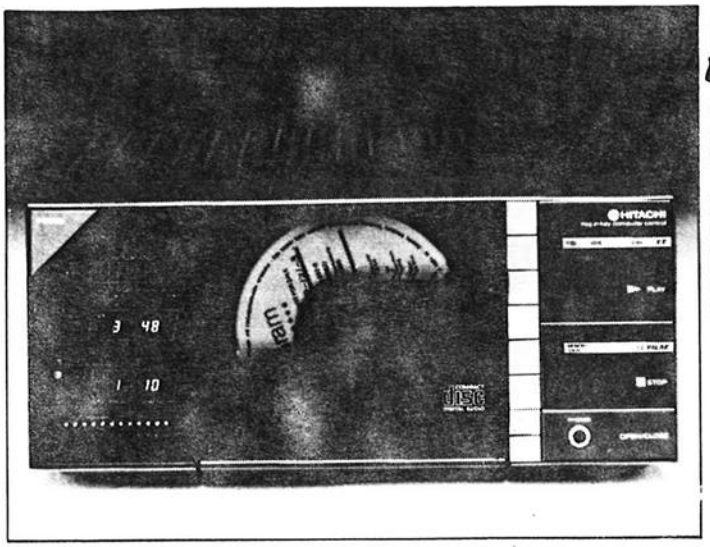
When a £430 CD player has the potential capability to outperform a £2000 + LP player (add another £1000 if state-of-the-art headamp and RIAA equalisation is included in the latter, as it should be), the decline of the LP is inevitable.

Briefly summarising the qualities of CD as compared with LP we have, in areas of the technical specification, the following:

a) Essentially flat frequency response over the audio band with much improved low frequency extension, in consideration of input matching, temperature, etc.
(Typically 5Hz to 20kHz±0.5dB).
b) Near perfect inter-channel phase and amplitude balance.
(20Hz to 20kHz±0.3dB, 5° max difference).
c) Very high stereo separation, more than 100 times better.
(Typically better than 80dB, 20Hz to 20kHz)
d) Low background noise, both in the audible bandwidth and outside it, 10 to 100 times lower.
(S/N ratio better than 90dB CCIR/ARM, 96dB 20Hz to 20kHz).
e) Completely negligible wow and flutter, 100 to 200 times better than LP.
(Measurement shows less than 0.001% DIN pk wtd).
f) Complete rejection of acoustic feedback effects, together with decent levels of mechanical shock immunity.
g) Complete absence of delayed reflections and mechanical resonances associated with analogue LP systems; coloration is by today's standards exceedingly low.
h) Uniform power bandwidth over the frequency range, avoiding the treble range compression of other reproducing systems. (The latter typically 5-8dB by 20kHz).
i) Uniform response and tonal balance throughout the duration of disc play primarily due to the constant linear velocity (CLV) of the modulation spiral.
(LP frequency range is curtailed with reducing diameter).
j) High level equalised output minimises demands on the preamplifier and makes a passive control unit entirely practicable (with sensible power amplifier input characteristics). (CD typically 2V RMS max. output from 600 ohms).
k) Very low levels of distortion and spurious modulation.
(CD typically -96dB at peak level, -70dB at 30dB below peak: LP -20 to -40dB distortion).
On the practical side, factory alignment of player removes the need for delicate dealer or consumer setting up.
m) Conveniently small, relatively damage-proof discs with foolproof loading.
n) Tidy players, at last dispensing with those easily marked and bulky plastic turntable lids.
o) Up to one hour (potentially 1hr 20min) of uninterrupted replay.
(LP 30 minutes maximum).
p) Disc is tracked by a non-contracting optical laser head providing virtually unlimited record life.
q) Sophisticated track selection; cueing, programming, display and remote control facilities may be readily incorporated.



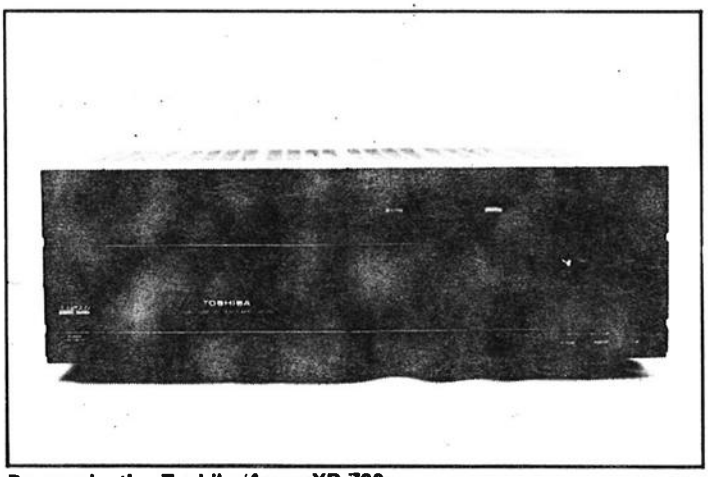
**Front-loader styling of Marantz' CD73**



**Hitachi's DA-1000 — for LED lovers?**

Lest one suppose that the whole system is now entirely cut and dried, the evidence of the reviews which follow suggests that, in addition to the features and facilities optioned on various machines, there will be considerable scope for down and up-market versions. Here the quality of the final DAC (digital to analogue convertor) is crucial, as are the following analogue electronics used for filtering, de-emphasis (when engaged) and output amplification. It will only be a matter of time and experience before the market can learn to identify subtleties of sound quality associated with circuit design in this area. Scope for innovation and improvement will remain.

While all the publicity seems so far to have been focused on the consumer benefits of CD, it is as well to consider the implications in other fields. Broadcasting is the first that springs to mind. Both the BBC and the independent broadcasting organisations make use of a huge amount of recorded material, whether as introductory or background material, or as recorded music programmes. With very



**Pre-production Toshiba/Aurex XR-Z90**

popular material, the record wear and damage rate is high, this leading to a significant overhead cost. Furthermore, with older material, it is often only too clear to the listener how poor a condition it is in. Program of archive quality available on conveniently small, easy-to-handle, discs will be a godsend to broadcasters. With appropriate machines, the microprocessor intelligence of the CD player can offer the professional instant cueing, rapid track selection, back and forward cueing — if necessary note by note — and accurate timing of the piece. Many longer works, symphonies and the like, will run on one side without a break. In addition to being freed from the problems incurred with analogue LP broadcasting, such as worn styli, the need for skilled handling, environmental contamination, notwithstanding the limited sound quality from LP, particularly towards the end of the side, the professional CD player will provide reliable high quality programming essentially of master tape standard throughout.

I can see musicians regarding this aspect with some disfavour since CD will increase the availability of first-rate recorded music in competition with live broadcasts. The technical quality of the recorded music output of BBC Radio 3 could be vastly improved, more or less overnight. Playing LPs at the wrong speed or with movements in the wrong order will become a thing of the past.

Remote control comes naturally to the CD player, and ergonomical- ▶

ly designed remote units for CD could be incorporated in the main mixing console of the broadcast studio. Already considerable research and practical work has taken place on totally digital mixing desks — tone control, equalisation and other signal processing being carried out on the signal in digital form — and CD output should logically be available in raw digital form, either compatible with or capable of being transformed to the standard in use in the studio desk. A long-term goal would involve digital audio transmission to digital tuners, thus eliminating the analogue defects of the FM encoding/transmitting-receiving chain.

Consider also the implications for lending libraries. While many librarians enthusiastically support a record section, its size and growth are severely hampered by the short life and high damage rate suffered by borrowed LPs. CD could transform the situation since, in theory at least, a Compact Disc will have a longer lifetime than a hardback book. At last, a library will be able to build a long-term record collection for public use with excellent audio quality; its untidy record racks perhaps being replaced by a neat compact shelf unit.

Even amongst friends, an enthusiast who would otherwise be wary of loaning a cherished LP would have little hesitation in parting with a CD record. And on the second-hand market, CDs would retain a high value since, unless badly damaged, they should play exactly as new.

While this review encompasses five models of CD player, in a sense it is as much a review of the medium as of the individual players. It proved surprisingly difficult to obtain sufficient test material, both musical and technical for the evaluation, and only after considerable pressure had been brought to bear on the various suppliers was it forthcoming. Particularly worthwhile was the acquisition of duplications of some program to allow simultaneous comparison of the playback quality of two machines at a time. In addition, analogue LP versions of several records were made available, allowing extended comparisons of CD and LP reproduction of the original master material.

## Technical test programme

A laboratory programme was devised to exploit to the full the possibilities offered by the available software. The appropriate test records are noted in the summary below.

1) Frequency response 20Hz to 20kHz, L & R channels (P).
2) Squarewave response 100Hz (S), 400Hz (P), 1kHz (S,P)
3) Total harmonic distortion (excluding noise) 40Hz to 20kHz, spot frequencies at full level, 0dB, and at -10, -20, -30dB(P) and 1kHz at 0, -60, -80, -90dB (S).
4) Spurious tone generation/demodulation noise: 6.3kHz, 10kHz, 16kHz, 19kHz, 20kHz at 0, -10, -20, -30dB (P).
5) Two-tone intermodulation distortion.
   i: swept $f_1$, $f_2$ with $f_2 - f_1 = 70$Hz difference frequency recorded,
   ii: 400Hz + 7kHz, 4:1 ratio, 0dB and -10dB,
   iii: 19kHz + 20kHz, 1:1 ratio, 0dB and -10dB.
6) Signal/noise ratio, CCIR/ARM, Audio band, A-weighted, wideband, 400Hz to 30kHz band for zero modulation and 'paused' mode.
7) Noise spectrum analysis, ultrasonic spuriae, to below -140dB, 1Hz to 100kHz.
8) Channel balance 20Hz to 20kHz amplitude,
   20Hz to 20kHz phase.
9) Channel separation 20Hz to 20kHz, loaded and unloaded.
10) De-emphasis check.
11) Error-tracking check, analysis where possible.
12) Wow & Flutter (confirmation of negligible level.
13) Track access time.
14) Mechanical noise level.
15) Output level and source impedance.

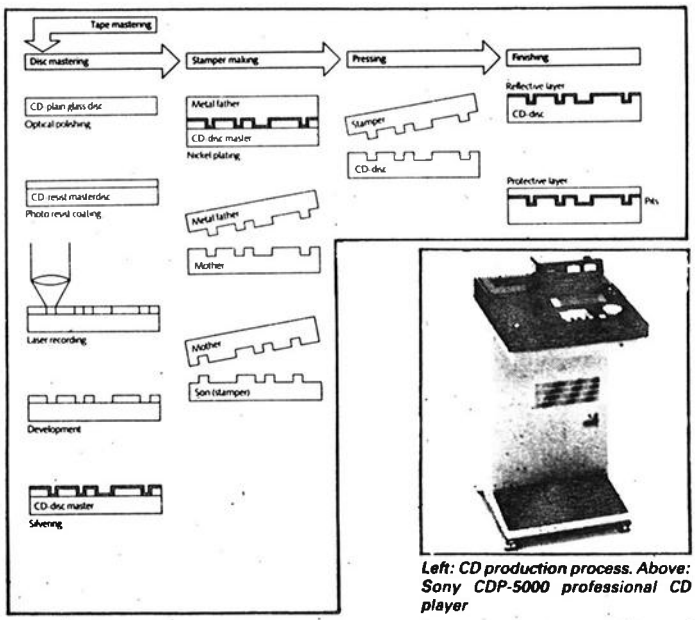
Test records: Philips 'Audio Frequency Test Signals No.3' DA-TD-1174, 57-7-15 July '82 (with B&K synchronised sweeps).
Sony 'Audio Frequency Test Signals CD type 1' YEDS 2 (spot frequency tones).
Polygram 'Error Correction Disc' 400079-2-06 (multiple music tracks with a variable width dropout).

These records are virtually handmade, and have very low intrinsic error rates. The test tones and sweeps are computer-synthesised, have no encoding error, and are generated to an accuracy of 6 decimal places, with distortion at 180dB (!) below peak level.

Many of the tests will be familiar to the more technically interested readers and are often performed on amplifiers. The error correction section relates to the internal operation of the player. The digital data on the disc is in theory protected by a generous redundancy factor of 25%. Given a perfect, error-free disc and good tracking performance on the part of the player (tracking in a CD context refers to good focusing and track following), this factor should indicate very good protection against superficial disc damage, abrasion, finger marks, and the like. Given a near-perfect test record and analysing the error signals within the player circuitry, its tracking performance can be assessed. Conversely, once a player's integrity has been established, the errors present in other mass-produced software can be quantified. It is known that, at present, a considerable proportion of the 25% redundancy on music CDs is taken up by 'pressing' faults. Four levels or orders of error correction are used at present: the first operates at the bit-stream level; the second at the sub-frame; and third at the full frame. All these provide perfect replay *ie,* any errors are fully corrected. The fourth level should only rarely be invoked and involves interpolation or substitution for the missing section of data, the insertion composed of an average of the previous and succeeding samples. If this fails, momentary muting prevents clicks appearing in the audio output. With well-manufactured discs, the possibility of an audible click in the absence of a mute is theoretically in the region of one every 5000 years, but with early software from the record companies' pre-production runs, the figure is much more often than this in practice. With a number of the discs available, and depending somewhat on the choice of player, level four interpolation occurred once or twice an hour, while the lower order correction circuitry was found to be in operation a substantial proportion of the time. Indeed, for professional applications, Sony and Philips have produced a fault analyser which provides a comprehensive assessment of all those software errors. On a more simple level, one can connect appropriate gates and triggered counters to the player to record the incidence of error correction 'flags' reported at the four error levels.

If a given disc has a significant error level, it may well play perfectly, but will exhibit a lowered tolerance to damage and contamination. Hence the current recommendation from the industry to take reasonable care of the discs, not to cover them with fingerprints, and not to allow them to become excessively scratched. In extreme circumstances, fine scratches may be polished out radially, using an acrylic polish; fingerprints may be removed by wiping the disc with a soft cloth moistened with dilute detergent.

Several factors have been blamed for the relatively high error rate occurring with present software. These include fine bubbles in the plastic medium itself; imperfections and pinholes in the aluminised reflecting layer behind the modulation contour; imperfections produced by faults in the injection moulding process. These can be expected to improve as production experience is gained, but at the moment yields of playable discs are still low, said to be around 50%.

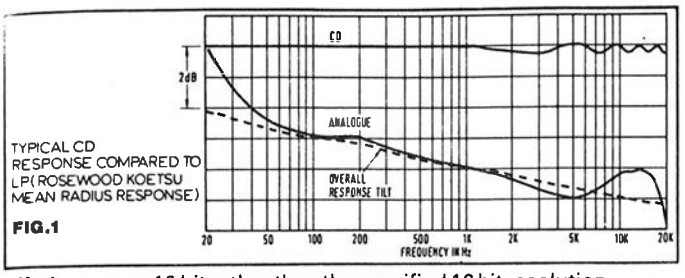



*Left: CD production process. Above: Sony CDP-5000 professional CD player*

An additional test was performed, comparing the peak spectral energy on music program between CD and LP.

## Subjective test programme

In addition to extended use in a high quality domestic replay system, the CD players were also subjected to comparative listening to assess the audibility of differences, if any. Two players were subjected to an absolute subjective test whereby several original digital master tapes (courtesy of Decca), replayed via the Decca custom decoder, were compared with the corresponding Compact Discs. A particular feature of the Decca program was its minimum content of repeat digitisation to preserve as much as possible the bit resolution present on the original recording. During the auditioning it became apparent that several of the CD records tried from other companies exhibited audible digital recording faults, including quantisation noise and spurious signals, indicative that the machines employed were ▶




TYPICAL CD RESPONSE COMPARED TO LP(ROSEWOOD KOETSU MEAN RADIUS RESPONSE)

**FIG.1**

offering nearer 12 bit rather than the specified 16 bit resolution.

It was considered important to establish a point of comparison between LP and CD replay quality. To this end, an analogue disc player of sensibly high quality, good tonal balance, and low coloration was assembled. This comprised a Linn Sondek LP12 (Valhalla'ed, felt mat), Alphason HR100S tonearm, Koetsu Black cartridge, and Sony Esprit preamp (m-c headamp not used). Prior tests had showed this £1000+ player to offer a fine performance and to be a near-state-of-the-art combination. Extreme care was taken over turntable adjustment, pickup alignment, and the general set-up.

During these tests, the digital source was found to be notably revealing, and initiated a reassessment of all preamplifiers to hand. Sound quality variations perceived via line level or auxiliary inputs were surprisingly great, and larger than had been anticipated.

The extended low frequency amplitude and phase accuracy of CD program also prompted a reappraisal of the bass performance required of the monitoring loudspeakers, while the clean recorded peak levels made it essential to use high peak capacity power amplifiers.

## COMPACT DISC TEST RESULTS: THE MEDIUM

### Auditioning

Fed a diet of well-recorded and well-mastered program, a competent CD player is capable of delivering a replay sound quality almost indistinguishable from that of the original master. The sound quality differences between players were surprisingly rather less than those observed between the auxiliary inputs of a number of very high quality audiophile preamps. Examined to a possibly over-critical limit, the audible differences between players working correctly can be discerned, but at our present state of experience only with some difficulty. Listeners possessing less critical attitudes to sound quality would be unlikely to perceive anything significant. Very few in today's industry would be prepared to argue against the contention that good studio master program quality greatly exceeds that available to the consumer via LP or prerecorded cassette. (But see Bernard Coutaz' piece on page 83 — **Ed**). CD, for that consumer, represents a dramatic advance in program quality.

#### Comparison with digital masters

Carried out at Decca's West Hampstead studios, comparisons of CD replay quality from Sony and Philips machines with the original tape demonstrated that the domestic replay standard was very much to that of Decca's very costly custom-built replay decoder. This is acknowledged to be one of the best in the industry and the tests provided convincing proof that Compact Disc provides a virtually transparent link to the recording studio.

Using an H&H MOSFET power amplifier and B&W 801 monitors (no preamp), the standard of reproduction was very high in a large monitoring room possessing fine acoustics.

#### Longer-term listening

With a reasonable selection of rock and classical music to try, the CD players were subjected to extended auditioning. On some material, production faults were clearly audible, which detracted from the enjoyment of the music, though from a technical viewpoint, the annoyance was no greater than that due to LP surface noises.

Interestingly, the very aspect for which the medium has been criticised by the detractors of digital I found to be its greatest strength, this being the ability for the listener to follow a tune. In this context, it means that the essential tempo, rhythm, and outline of the music are easily followed by the listener in a relaxed manner, free from fatigue or any feelings of strain. We were consistently impressed by the way in which digital playback — even recordings with a second-rate balance or perspective — conveyed perfectly the timing, rhythm, and clarity of the music. The pitch indecisiveness that we have long put up with on analogue disc is entirely absent. The CD bass is taut, effortless, has satisfying extension, and is free from boom and other colorations.

The stereo presentation from CD accurately reflected the original production, warts and all. Tasteless multiple microphone arrangements were ruthlessly revealed to the extent that almost every microphone, with its own coloration signature, could be discerned scattered amongst the falsely staged soundfield. The stereo focus, precision, and stability were remarkable on good material. The perception of fine detail seemed effortless, and from good sources, the feeling of transparency and depth were delightful. Complex musical peaks were reproduced with satisfying realism, free from compression and muddle.

Another aspect of Compact Disc may well cause problems, however, if CD is introduced into existing analogue replay systems. Let us, for the sake of discussion, take a classic LP record orientated music system, based on Linn and Naim components. Such a system has for many owners demonstrated a symbiotic and synergistic effect with respect to the reproduction of LPs, particularly of rock music. Such an intimate relationship would suggest that these components may not thrive if separated. Inserting a 'foreign' program source somewhere down the reproducing chain may not produce the desired result.

If the essential sound character of a top-class record player is examined and compared with the original source, several points are relevant. The subjective tonal balance tends to richness, due to the generally down-tilted response of most moving-coil cartridges. In situ, these show with respect to the 5-10kHz range some 1-2dB of shelf bass lift, often with an increased rise below 40Hz. Above 10kHz, the low level outer band measured frequency response may be flat, or even slightly rising. However, when averaged over a record side, wavelength tracing limitations produce an overall upper treble response 2-3dB down. On high level peaks, the treble content falls a further 2-4dB. The overall effect is that of a tilted response falling gently from 30Hz to 20kHz by a total of 3-6dB (fig. 1). Add to that the slight bass boominess and overhang present in many sub-chassis turntables, plus the mild midrange forwardness and thickening present on vinyl discs on a preferred — by myself included — felt platter mat, and the subjective tonal balance is weighted even further.

Leaving aside for a moment the subjective effects of distortion in the treble ranges from vinyl records, we must also consider the amplifier/loudspeaker relationship that would provide a satisying effect from such a program source as described. By implication, those components in combination should possess a tight, possibly overdamped, bass register with some measure of infrasonic filtering to exclude spurious low frequency noise magnified by the cartridge/arm resonance. One could anticipate a mildly rising response through the upper midrange, with decent output in the presence band to preserve openness, transparency, detail, and transient 'attack'. A dispersed lively treble would also be a feature. In general terms, this scenario is a reality for the optimum Linn-based system.

Now when a flat response, neutral source such as a Compact Disc player is inserted, the result is inevitably a bright, cold tonal balance, with a dry bass, a forward, almost metallic presence register, and a stinging brittle upper treble. It follows that the most natural sound quality with CD will be obtained from a neutrally balanced hi-fi chain that has not necessarily been aligned for optimum sound from certain top quality moving-coil cartridges, including their accompanying turntables. As with all new program sources, some acclimatisation is required to appreciate fully the intrinsic sound quality and its integration with the existing system. Some trial and error experimentation will be required to achieve the best results.

Turning to the digital versus analogue comparisons, these were performed with in the main four recordings: *YYZ* by Rush; *Love over Gold* by Dire Straits; *Traviata* excerpts featuring Pavarotti and Baker (Decca); and Wagner's *Flying Dutchman* overture on Philips.

With care, it proved possible to make useful judgements on passages where the analogue section was near the LP rim. Here, mid level sound quality on the admittedly very costly analogue system was not too far removed from Compact Disc. Some loss of detail and depth was noted, as well as a mild degradation in stereo focus and some coloration, this evident over many areas of the frequency range. Towards end-of-side, the deterioration audible on the LP replay — increasing muddle and increasing treble loss — made further comparison pointless. During quiet passages, comparison was also of little value since the analogue surface noise level was subjectively 10-20dB higher, lending a brightening and masking effect. On climaxes, the analogue replay again caused difficulty, showing a failure to maintain the brilliance and sharpness of live transients. On complex loud sections, the LP sound showed a blending and mixing effect, while on CD each musical strand was preserved intact and was separately audible. This was particularly noticeable on the *Traviata* recording where soloists and choir sing together. (The player used at this stage was an Oracle, Audio Technical AT1100 arm and a B&O MMC20CL — worn — and the improvement upon switching to CD was a revelation.)

On program with good bass, the digital replay demonstrated a markedly higher standard. So much so, that I have been forced to

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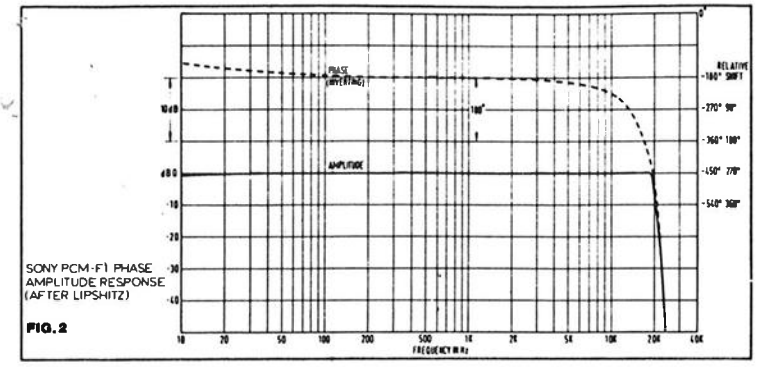


SONY PCM-F1 PHASE AMPLITUDE RESPONSE (AFTER LIPSHITZ)

**FIG. 2**

◀ reconsider my requirements for necessary low frequency bandwidth. Before Compact Disc, I had been quite happy with an integrated room response -3dB at 40Hz, this within the compass of the Quad ESL-63, Spendor BC1, and Celestion SL6. Now I am re-investigating the applicability of subwoofers — the Audio Pro B2-40 has come back out of store for further trials. Initial work with SL6s suggests that the latter may be left unfiltered, while the B2-40 is set to a 1.5-2V sensitivity and a 50-60Hz cut-off. The subwoofer is rarely heard as such, and yet on much CD program it adds an almost indefinable weight and substance to the SL6 reproduction, immediately noticeable if it is disconnected.

## Laboratory test results

We have at last been provided with the means to measure by established standards how successful the designers of hardware for CD have been. By and large, the test results in numerical terms were very good and not dissimilar to those one might expect from the line or auxiliary inputs of a good quality hi-fi preamplifier. Consequently, considerable care was required in the laboratory to ensure that the figures presented were representative of the devices under test and not just equipment residuals. Some idea of this problem may be gained from the specification of the usual and rather costly (£6000-£10 000) FFT digital analyser, this possessing 12 bit resolution (70dB on paper, 4 bits poorer than the players under test). Conversely, the normal THD analyser will measure to typically -85dB, but not in the presence of some of the residual out-of-band spuriae from the output of many digital player designs. For example, a 24kHz ultrasonic tone at a harmless -70dB level will prevent most distortion analysers from measuring below that threshold level. However, to assess properly the linearity of a Compact Disc player, the measuring system must be capable of resolving to at least -110dB referred to full or 0dB modulation level.

Cascading a distortion analyser with a spectrum analyser would allow sensible measurements to be taken, though this is undoubtedly a very time-consuming process. It would seem that digital audio systems have, for the time being, surpassed the performance of audio measurement systems.

### Dynamic range and linearity

These two parameters are prime targets for the reviewer — are they as good as has been claimed? The answer is 'Yes!': the best players showed harmonic distortions in the midband at -95dB or better. Audio band noise levels were in the same region, as is crosstalk between the two channels. With good samples, it should be possible to perceive information to below -100dB, more so if the de-emphasis option, incorporated but as yet unused, were to be employed.

### Frequency response and spuriae

The players have shown that spurious noise signals can be held to low levels, and that wide and extremely flat frequency responses are possible, with excellent channel balance, and very good-to-perfect phase correspondence. Certain players, with a time-shared D/A section — the configuration commonly used — do generate a small differential delay between channels. This corresponds to half a 44kHz sampling interval, or about 90° at 22kHz, a 1/4 wave delay. At 20kHz, 75° relative shift was found to be typical, this reducing to a small 3-5° at 1kHz. Putting this time difference between the channels in context, it corresponds to a physical imbalance in the distance between the listener and the left and right loudspeakers of just 3.5mm — in my view, this is negligible. Under very critical conditions, it is possible to detect spacing errors of 25-50mm (see my review of Carver's Sonic Holography Generator Jan.'82) but the results from the CD players with this effect would presuppose a head clamp!

### Absolute phase compared with Sony's PCM-F1

The absolute phase response of the players could not be measured directly, but could be inferred to some extent from the squarewave/impulse responses. Clearly the phase characteristic is superb up to many kHz, above which it deteriorates rapidly as the steep cut-off filter at 22kHz is approached. Our understanding at present of the audible effects of phase aberrations suggest that low frequency phase errors are considerably more important than those at high frequencies, and that reasonable levels of overshoot — 6-15% — and ringing at the upper cut-off would not seem to be important. An idea of the total phase response of a 16 bit record/reproduce chain is given in fig. 2, sent to me by Stanley Lipshitz, taken on the F1.
(Incidentally, I neglected to check the absolute phase of the F1 in my review — *HFN/RR* Oct.'82 — and note from Stanley that it is, in fact, inverting.) On the material we tried, this did not seem of consequence, but a proportion of the residual insertion error heard occasionally on the PCM-F1 may simply have been due to its absolute phase inversion.

### Wow & Flutter and Error correction

Wow and flutter were below measurement limits, and to all extents do not exist with Compact Disc.

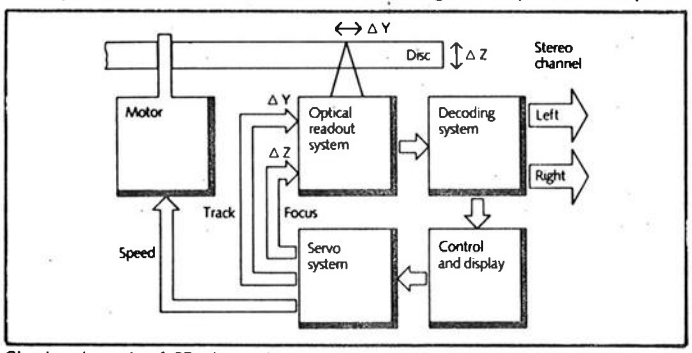
Employing the Sony CDP-101, which seems to be a pretty reliable tracker, the interpolation error rate on a number of music records was assessed and found to be satisfactorily low at one per 1-10 hours' playing time. No audible effect could be attributed to much greater bursts of interpolation, induced by mechanical shock or physical pressure on the laser traverse gantry. The error check record showed that severe gaps in the modulation, if of a concentrated nature, were competently corrected by players, proving the inherent damage resistant nature of the Compact Disc standard.

The test results suggest that as regard measured performance, the best CD players would show noticeably impaired results if measured via many high quality preamps.

## COMPACT DISC — THE MEDIUM: GENERAL CONCLUSIONS

Compact Disc replay is potentially the most perfect stereo program source accessible to the home consumer. Its intrinsic fidelity equals and in some cases surpasses that of some of the industry's finest electronics. It leaves vinyl LP, cassette, and tuner sources far behind. As the manufacturers concerned gain experience, some further improvements may be expected and the minor inconsistencies noticed at the moment will quickly be brought under control. Consequently, all purchasers of decent players can anticipate a consistently high level of replay quality.

Engineers will have to reconsider the design of amplifiers to exploit

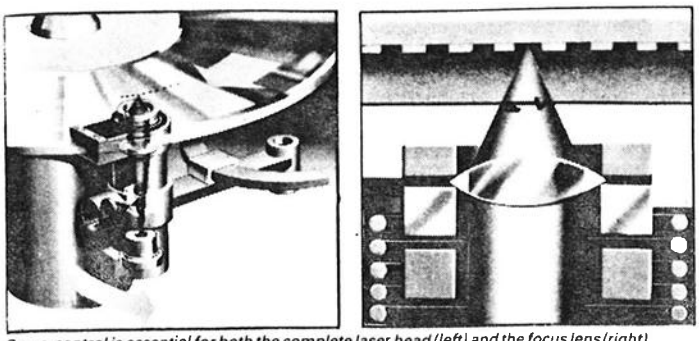


*Simple schematic of CD player electronics*

adequately the medium's potential. Listeners will become more aware of the need for firmer, more extended bass response, greater transparency and stereo focus, and higher peak dynamic range, particularly in the upper treble registers. Loudspeaker designers will have to meet a similar challenge. Analogue turntable systems will have to be more competitively priced to maintain some measure of credibility; system matching and alignment and LP pressing quality need further control. Reproducing systems optimised for CD replay may not extract the most musical results from LP records unless the trends in analogue design move to a closer subjective response when compared to digital.

Consumers who have experienced an intelligently set-up demonstration of high quality digital program are more than likely to consider CD player acquisition a first priority. Many of the consumers in the home may be attracted by the excitement and quality of the new system. Market research suggests that player purchase would be a serious proposition for many owners of even comparatively modest hi-fi systems down to around £500, despite the relatively high price of the digital machine. Enthusiasts with good existing systems will represent a strong sector, viewing CD as a sensible first choice in the upgrading of their gear, particularly when an improved analogue turntable set-up is the alternative.

Far from Compact Disc causing a general malaise and retrenchment in the recording industry, concerning its attitude to recorded balance and production, I see CD as initiating a dramatic rekindling of enthusiasm for more accurate, musical and realistic recordings. No longer will the record producer need to consider the artificial



*Servo-control is essential for both the complete laser head (left) and the focus lens (right) the latter picture showing how surface imperfections don't affect the light beam*

techniques at present considered necessary to compensate for the deficiencies of stylus/vinyl groove replay. Indeed, such artificiality, will be abundantly clear to record critics using CD player for assessment, and this will prove to be a powerful force for change.

For sensitive skilled producers, the quality of their work will be revealed by CD, whether the original master be analogue tape or digital. One of the first popular CD records so far available is *Love over Gold*, yet the LP simply does not do it justice, although the original was a 76cm/s open-reel master, not digital. All existing good quality master material, regardless of its vintage, can benefit from CD.

While no-one in his or her right mind would give up the wealth of material already published, or indeed owned, on LP, at the same time I feel that no-one interested in quality audio and who loves music can afford to be without Compact Disc.

Other domestic digital replay systems have been proposed, and eed, demonstrated *eg*, Soundstream's AudioFile [*HFN/RR* Jan. '83] but economically viable, compact, large volume production models are possibly years away. The value of Compact Disc is that it represents an agreed worldwide domestic standard, and that it is in production and available here and now.

## THE PLAYERS

The designs covered by this review include the Denon DCD2000, Hitachi DA1000, Marantz CD63, Marantz CD73, Philips CD100, Sony CDP-101, and Toshiba/Aurex XR-Z90.

While all the seven players listed above were physically examined, close similarities between some of them meant that a smaller number actually needed to be lab tested and subject to detailed evaluation. For example, Hitachi (LoD in Japan) make both the DA1000 and the Denon machines, these being virtually identical. The Marantz CD63 and Philips CD100 are also similarly related, while the CD73 uses Philips electronics in a Japanese-built housing, the latter providing drawer-type front loading and an optional remote control facility. As a result, it was only strictly necessary to subject the Hitachi, Philips, Sony and Toshiba machines to the measurement programme.

It has proved difficult to extract firm price information from the manufacturers concerned, but the following is our estimate of typical UK selling prices at the time of going to press.

| | |
|---|---|
| Denon DCD2000/Hitachi DA 1000 | £540 |
| Marantz CD73 | £460 |
| Marantz CD63/Philips CD100 | £425 |
| Sony CDP-101 (remote) | £499 |
| Toshiba/Aurex XR-Z90 | £590 |

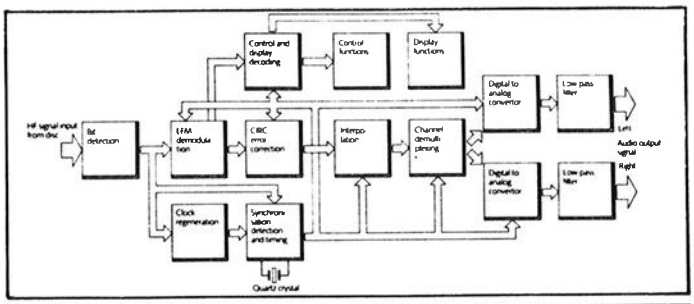
In size the CD63/CD100 design is the most compact of the group and hints at even smaller models to come. Being a top loader, in this case access to the turntable hub is obtained via a small transparent lid. This model is relatively easy to make, and being simpler than the others mechanically, it could well prove more reliable. Many admired its non-technical, 'friendly' looking controls and appearance. The slimmest looking of the machines is the Marantz CD73, which will slot into many existing rack systems. Visually impressive, with many LED indicators, the solid action of its front loading, motor-powered drawer mechanism will appeal to the more technically minded buyer, and it also possesses some embellishments, these including rear connection for an optional remote control unit, soon to be released.

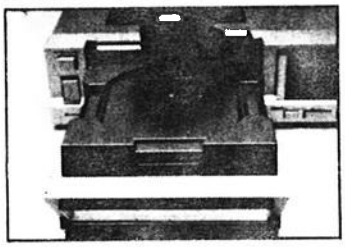
Sony's first design is also quite tidy, and is the least flamboyant of the group, with a minimum of flashing lights. The dark sombre clothing matches the Esprit range of electronics and its front loader mechanism has also allowed a relatively compact size to be achieved.

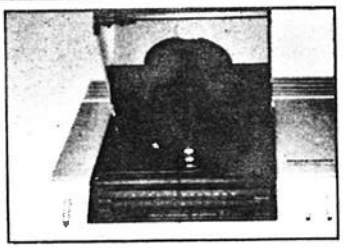
Possessing an increased height dimension as well as rather greater size all round, the Toshiba is much the same in volume terms as a conventional large integrated amplifier. It uses the vertical presentation method, as does the Hitachi, this allowing sight of the rotating disc from the listener position — either a plus point or a distracton depending on one's personal viewpoint. The Toshiba is 13.5cm high and the Hitachi 14.5cm as compared with the Philips at just 7.5cm. At present none of the players can display information which will in future be encoded on CD, this covering titles, track names and even libretti. The Sony, though, amongst other things does have an accessory port for connecting a display unit at a later date.

In operation the players are distinctly different as regards 'feel' of controls, as well as the facilities provided. Furthermore, some of them, notably the Philips and Marantz models, are comparatively lethargic in selecting chosen tracks, while others are very rapid. I found it reassuring to be able to enter a track number on the Toshiba and hardly have time to reach for the volume control before it began — perhaps one appreciates instant obedience from machines. On the other hand, with the Philips design, one felt that it was thinking its way from track to track. As it stands, the Sony seems rather sparsely endowed with a simple control panel and a two window display showing track number and elapsed time, but in fact it is rather more sophisticated than it looks, and includes slow and fast traverse cueing, with the scanned music audible, albeit in interrupted attenuated form (akin to picture search on a video). This proved invaluable in selecting precise start points and made repetitive track testing much easier. All these and more facilities are present on a remote control which was a joy to use; a numeric keypad allowed rapid entry of the desired track numbers which were accessed directly after about a one second delay. Machines lacking a numeric keyboard made number entry rather slower since these now had to be entered step by step on one or two keys only — these included the models from Philips, Marantz and Hitachi. The latter was particularly annoying since its fast forward or return jumped complete tracks and did not allow for any cueing within a track. In addition, both the 'stop' and the 'program' buttons needed to be depressed in sequence before a new track number could be entered. Only the Toshiba and Sony machines could enter track numbers greater than 15, but as one test record had 30 tracks, this made access to the second set of 15 somewhat of a hit-and-miss affair. Of course, it is possible to access the higher track numbers by stepping forward repeatedly and such a record will, in any case, play right through in the normal way, though without track number indication.

Some machines usefully provided headphone outputs (Sony and





*Top: Complex decoding has to be performed on the data stream derived from the disc, whilst solutions vary to the physical problem of loading it: simplest is perhaps the Phillips while Sony and Marantz offer retracting trays.*

Hitachi), while the Toshiba and Hitachi had a second pair of sockets with a variable output level. All used phono sockets, which in the case of the Japanese-built machines were gold plated.

A feature to weigh against the considerable advantage of the Sony remote control, is the random track programming of the other machines — an ability to enter tracks in any order in a memory store for the unit to subsequently replay as programmed, a feat the Sony cannot do.

**Design**

The essentials of CD recording and play have been covered in previous articles and there is insufficient space to properly describe the intricacies of the internal design of the various players tested.

However, there are several points worth noting. The optical systems reflect different methods for track aligning and tracking error detection, the more advanced models using two servos for laser advance across the disc. One covers full radius/prime traverse, while a second smaller 'piggyback' or tracking servo on the laser heard itself ▶ 56

provides fine tuning of tracking. The machines so equipped are those capable of fast track access times and exclude the Philips-based models.

The players also use different arrangements for focus error detection. Sony and Hitachi employ a cylindrical lens in the optical path which generates a bi-axis signal depending on the direction of the focus error, with a quadrant of photo-diodes then producing a specific output polarity proportional to the error axis detected.

Toshiba's focus detector uses two photo-diodes and a prism, utilising the threshold angle detection method. A 90° prism in its normal internal reflection mode only passes a maximum intensity, optically normal (perpendicular) output ray if the incident ray is also normal on the alternate face. Changes in focus produce a ray angle change and consequently differential changes in the output of the photo diode pair.

In the Philips decks a knife-edge is present in the optical path at a second mode or focus point, and depending on whether the error produces a focus point before or after the edge, one of two photo diodes becomes more illuminated than the other, thus providing the electrical output control signal required.

Estimated statistical life of the CD player laser is currently 2000 hours — this a broad consensus figure from the different optics manufacturers involved. Cost of replacement is indicated as around £100. These figures should be put in context by comparison with high quality moving-coil cartridge stylus life of some 500 hours at a similar replacement cost.

Turning to tracking error detection, Sony and Hitachi have adopted a system whereby the laser beam is divided into three spots each detected by a separate photo diode. The central diode is, in fact, the four-quadrant unit also used for focus sensing, and it additionally recovers the modulated digital signal from the disc. Philips/Marantz employ a pair of side-by-side diodes which simply detect lateral displacement error of the single laser spot on the track centre, while Toshiba use another four-quadrant photo-diode, here with a time difference detector analysing the outputs of opposing quadrants. That difference and its polarity corresponds to the tracking error.

Having recovered the modulated signal, it is the duty of a number of advanced digital circuits to translate this signal back to the digital bit stream which represents the original analogue signal, and which is suitable for decoding in the DAC (digital to analogue convertor), at whose output normal analogue electrical music signals reappear. Before reaching the D/A stage, however, complex error checking and

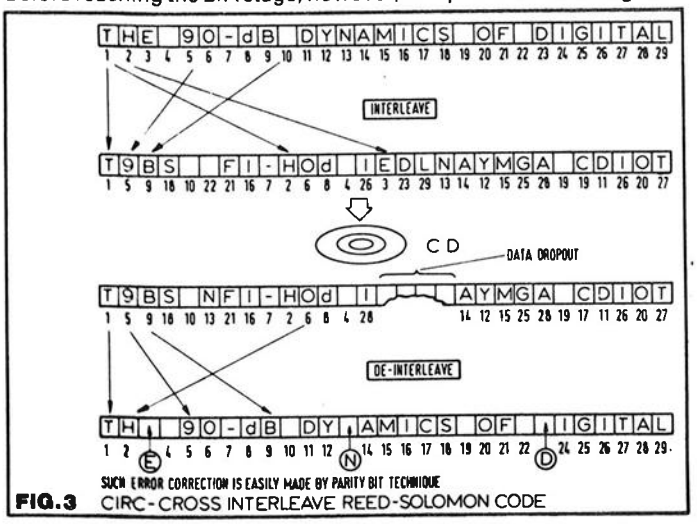



**FIG.3** CIRC - CROSS INTERLEAVE REED-SOLOMON CODE

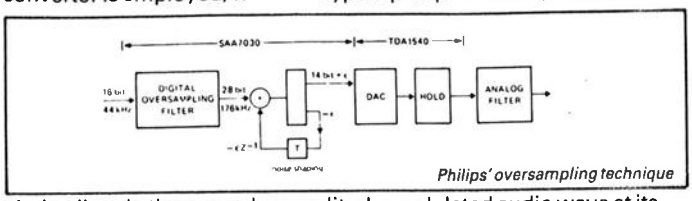
processing routines need to be carried out to ensure accurate digital data. One of these comprises the CIRC or Cross Interleave (Solomon) Reed Code technique, whose working principle is illustrated in the diagram above.

### Interleaving

A section of code from 1-29 is paired with a version which has been interleaved according to a predetermined pattern or code. For example, the letter 'H' of the legend in position 2 appears in position 10 on the interleave, which incidentally looks like gibberish. The interleave has dispersed each word of the legend over the entire block. Upon replay, a large error or dropout has occurred in this example over four successive bits, positions 15 to 18. It can be seen that only one letter is missing from three of the five words upon de-interleave. Single bit errors' such as these, may be corrected using the common technique of parity bit check, where the addition of check bits in a particular sequence may be arranged such that the sum of a given group equals a known value. By using a matrix which defines each bit position, individual bit errors can be found and corrected.

In practice, highly complex interleave strategies are used to provide a high error protection for CD replay. For example, in the Sony deck the number crunching required to compute the error correction algorithms is subtantial, using a microprocessor running at 2.6MHz, plus a random access memory of 16K capacity and an associated arithmetic unit integrated circuit. The latter's complexity may be partially inferred from the large number of lead-out pins on the chip totalling 60 in all.

Once the corrected digital data is obtained it is arranged in 16 bit serial or sequential form. In the Sony an integrating, constant-current convertor is employed, with a 'D' type flip-flop at the output to absorb




*Philips' oversampling technique*

timing jitter in the raw pulse amplitude modulated audio wave at its output terminal.

In common with others, Hitachi found difficulty in using the normal DAC form, thus employing a 16 resistor reference ladder. The problem is understandable since the precision of this ladder must be superb — if the first resistor is 1 or a unit value, the 16th must be 1/32768th.

In the Hitachi chip, errors in the resistor ladder are measured internally and stored as corrections in a memory section within the chip. During play this correction data is fed into the convertor to linearise the output and, for example, to make it temperature stable. Technics are known to have resorted to costly laser trimming to set a high ladder precision on their D/A chip.

Philips have developed a novel system to achieve high correction linearity and, in addition, they have avoided the problem of using an analogue brickwall filter to remove ultrasonic spurious signals above 22kHz. Instead they use a very fast 14 bit high accuracy convertor, (much easier than 16 bit) which is run at four times the normal 44.1kHz clock rate *ie*, 176.4kHz. This is called over-sampling, and in effect results in a 28 bit/step resolution at this stage. The signal is then rounded off to 14 bits with its noise and distortion spread over a bandwidth equal to half the new sampling frequency (*ie*, 88.2kHz.) A digital transversal filter is used to generate a linear phase pass band to the audio range, final spurious attenuation being provided by a slow roll-off analogue Bessel filter placed after the conversion.

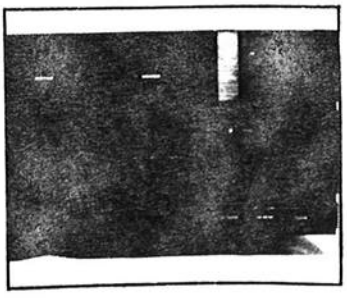
Since the dynamic range is referred to an 88kHz noise distortion bandwidth, that remaining in the audio 20kHz bandwidth, together with the improved resolution due to the smaller, faster equalisation steps, results in an overall 16 bit conversion accuracy, and avoids the usual critical analogue output filter. The transversal filter/DACs could not be time shared and hence two such chains are used by Philips, one for each channel. Because a transversal filter is equivalent to a cascade of time delays it does not provide an absolute time reference and it cannot deliver a conventional pulse response. Thus the Marantz/Philips players should offer improved pulse overshoot, but transients will be symmetrically reproduced in the time axis, apparently ringing in a fixed time delay between channels, this noted earlier. Variations in the choice and alignment of the necessary output filters of CD players can be expected to continue to provide small differences in phase and frequency response.

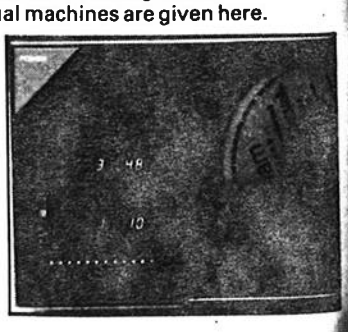
Considering the high mechanical and electronic content of a CD player, I am surprised that the manufacturers are able to sell them at the £500 level, as in my view, to judge by their interior engineering, I would have thought that £1000 would be a more realistic amount.

One must assume that the industry is hoping that there will be a rapid climb to the high volume production levels which can provide savings on a scale that will justify an initial uneconomic launch price. This situation must also be true of the discs, in view of the present capital investment required for a CD record pressing plant.

## CD Player test results

Results have been given earlier for the medium in general; accordingly, the results for individual machines are given here.



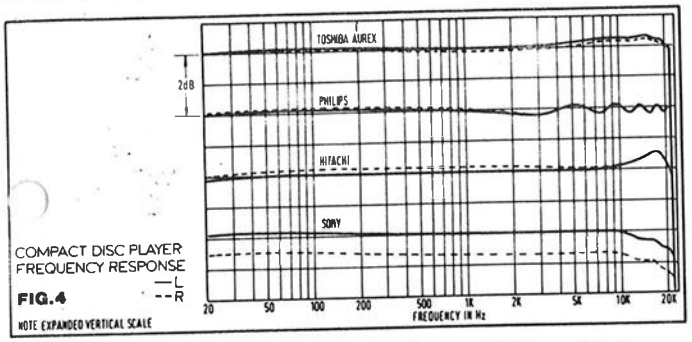


**Sound quality**

Induced to place the models in order of preference, I have done so, but would point out that at the time of review some of the players were rather immature in development terms, and could well have been improved or corrected by the time of going to press. However, in mid January the order appeared to be: Toshiba, Sony, Philips/Marantz CD63, Marantz CD73, and finally Hitachi.

The running was undoubtedly very close for the first three, with separate tests proving the Sony and the Philips players to sound very similar to original recordings. On A/B tests the Toshiba appeared to sound (very marginally) more open and transparent, with no loss of apparent depth. Our Sony sample sounded very slightly dimmer and slightly more detailed than the Philips, but only just.

The Marantz CD73 front-loader was present for physical examination only, due to a known mild subjective performance shortfall, this confirmed on test. The effect was disturbingly subtle and with extended listening, it was felt that the CD73 gave a little more grain and sibilance in comparison with the other, and somehow appeared less subjectively involving. The Hitachi, however, was distinctly different. This model, while pitch stable, dynamic and alive,




COMPACT DISC PLAYER FREQUENCY RESPONSE —L --R

**FIG.4**

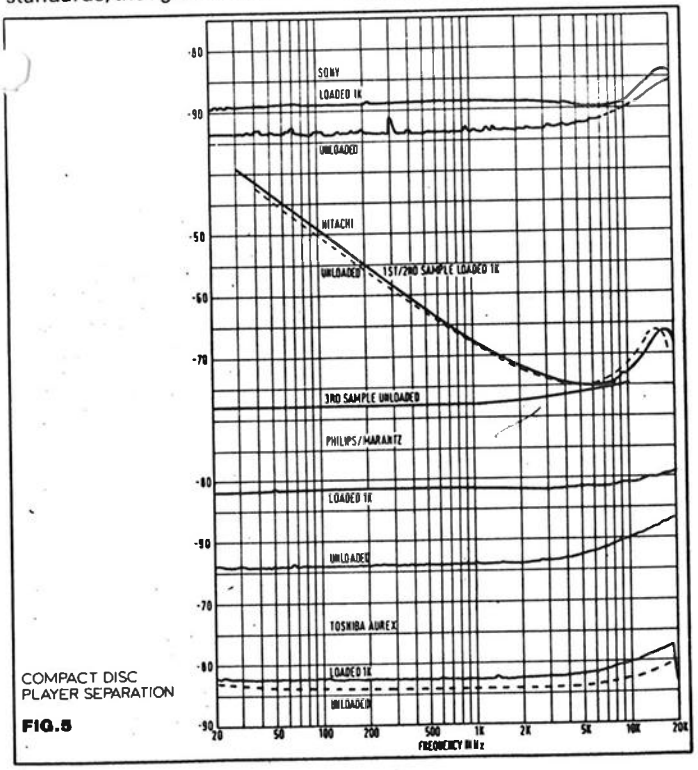
NOTE EXPANDED VERTICAL SCALE

also exhibited noticeable brightness, grain and sibilance, plus a reduced resolution of depth and detail. We subsequently learned that the trial and review stocks of the DA1000 sent to Europe at press time had a serious distortion fault (see lab results).

With the CD73 and Hitachi put aside for the present, the audible differences between the 'sound' players as I have pointed out earlier, were comparatively small. Even by audiophile standards, the replay fidelity must be considered very good indeed on well mastered program. On low level passages with the volume turned right up (unrealistically so), some faint whistles could be heard in the Hitachi background, but with the other models these were inaudible. Conversely some second-rate digital program exhibited whistles obviously present on the master.

**Laboratory performance**

The frequency response of all the machines was very flat by normal standards, though residual small differences suggested that under



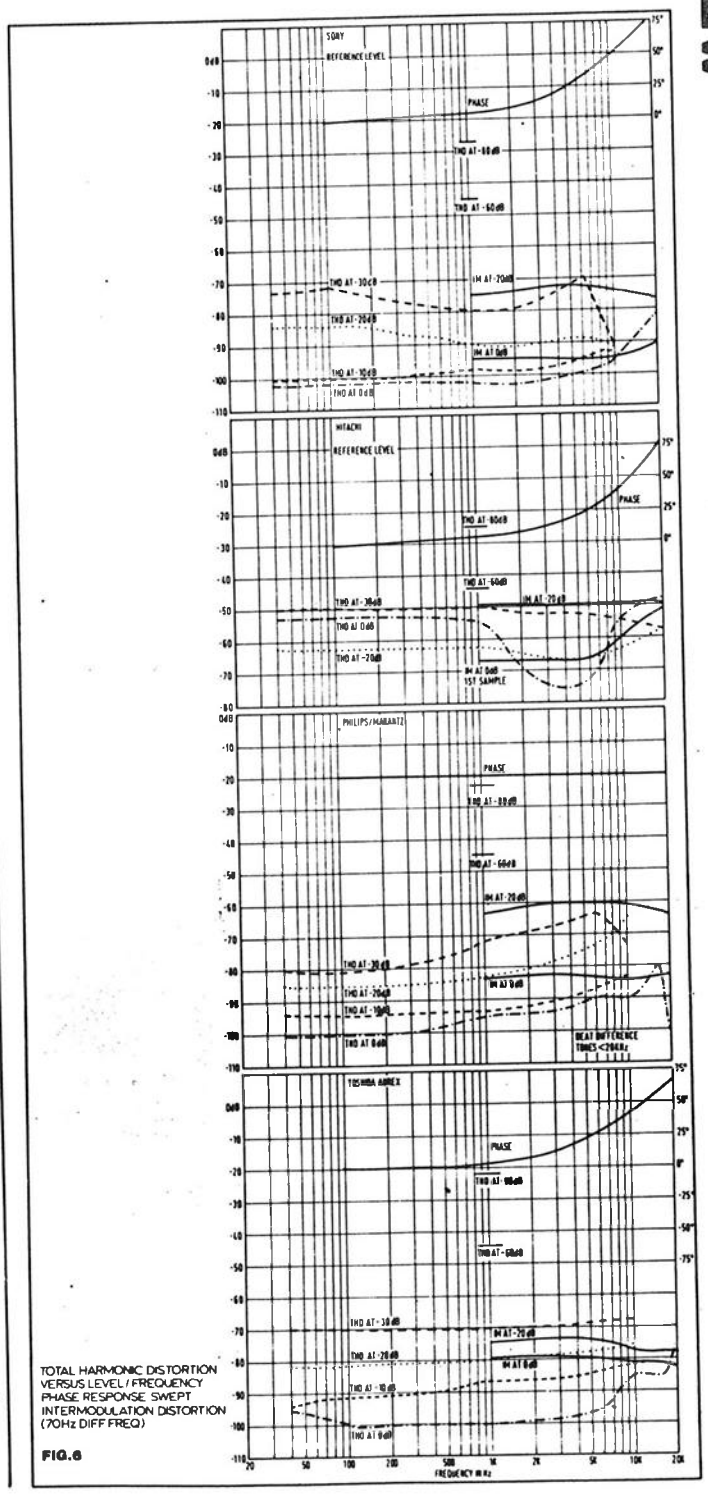

COMPACT DISC PLAYER SEPARATION

**FIG.5**

critical A/B subjective comparisons they could be told apart. For example, taking the Toshiba and the Sony, the former was flat in the bass with an 0.2dB shelf boost from 6–18kHz and the latter 0.2dB boosted in the bass, showing a treble roll-off above 10kHz this averaging −0.4dB. Certainly the Toshiba will sound slightly brighter than the Sony, while the Hitachi will be brighter still. In any case, the block filter design models, such as the various Japanese examples, may well vary slightly from sample to sample.

All the machines exhibited superb channel uniformity and fine balance, with the Sony the poorest at 0.7dB, still a pretty good result. This was due to a maximum tolerance of 0.5dB from the convertor and 0.5dB due to the filter, but subsequent production machines will reduce the convertor to 0.3dB. The phase balance was another matter, this already discussed in the general results, and I do not feel that the phase differences noted will in practice prove a subjective problem.

Channel separation bettered 85dB over the whole frequency range with the better machines, this showing some degradation on a 1k-ohm termination loading, as in the case of the Philips. The first two Hitachis gave much poorer separation, down to 35dB at 20Hz and 68dB midband, but a third sample measured 78dB, reducing to 70dB



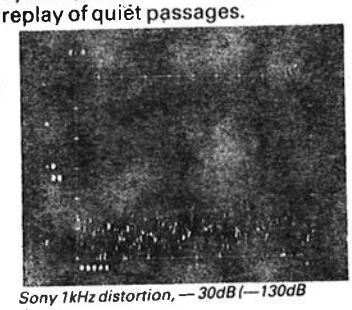

TOTAL HARMONIC DISTORTION VERSUS LEVEL / FREQUENCY PHASE RESPONSE SWEPT INTERMODULATION DISTORTION (70Hz DIFF FREQ)

**FIG.6**

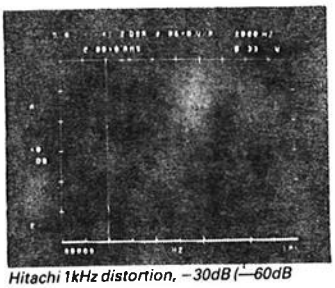
▶ 58

◀ at 20kHz.

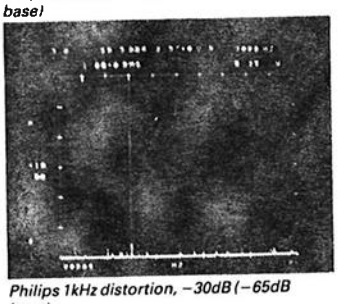
Assessed via post spectrum analysis, the total harmonic distortion, excluding noise, can be seen to be remarkably low. (This doesn't include the Hitachis which at present are suffering from a serious linearity problem in the upper 8 bits of conversion.) The others reached an extraordinary 100dB at low to mid frequencies and although the graphs show some variation with frequency, one should remember that above 10kHz the harmonic distortion products are actually outside the measurement and player bandwidth. In consequence, the tabulated results refer to the downband beat products. In the case of the Sony spectrogram, 0dB full level, 20kHz (the almost suppressed signal at the fourth lateral division) the spurious tones appear from left to right at approximately 4kHz, −86dB, 16kHz, −78dB, and above audibility, 24kHz, −54dB. They arise from mild non-linear multiplication with the main sampling frequency 44.1kHz *eg*, with the second harmonic of 20kHz subtracted we get 4kHz, while the third harmonic with 44kHz subtracted results in 16kHz, etc etc. In a sense these are inharmonic distortions which fortunately occur at a satisfactorily low level and only in conjunction with large recorded signals right at the band edge. A cymbal crash, for example, would contain so much fundamental energy in addition to its harmonic spread to beyond 20kHz, that such side tones would be inaudible on replay. However, if a recording arrangement were to allow a near inaudible 20kHz region whistle due to a fault to enter the system, then the resulting beat tones could well be audible on the replay of quiet passages.



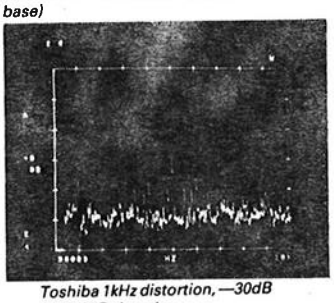
*Sony 1kHz distortion, — 30dB (—130dB base)*



*Hitachi 1kHz distortion, −30dB (—60dB base)*



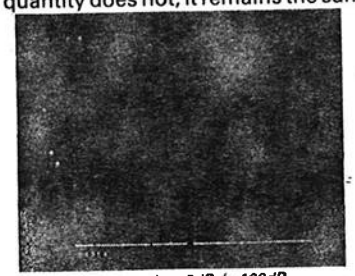
*Philips 1kHz distortion, −30dB (−65dB base)*



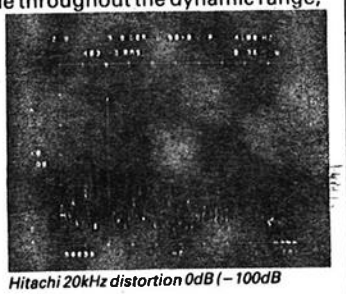
*Toshiba 1kHz distortion, —30dB (—100dB base)*

Distortion measurements were continued to very low levels, and it is worth noting that even at 60dB down, a point of virtual extinction with analogue players, the digital distortion is a little over 0.5%, this with a reasonable A-weighted signal/noise ratio of 39dB.

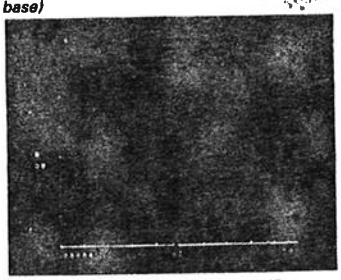
It would appear to be a fallacy to say that digital distortion increases with reducing level. Sure enough, the percentage changes, but the quantity does not, it remains the same throughout the dynamic range,



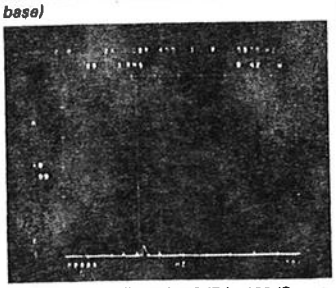
*Sony 20kHz distortion, 0dB, (−100dB base)*



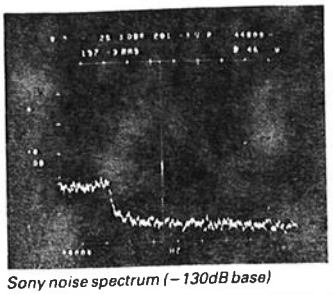
*Hitachi 20kHz distortion 0dB (−100dB base)*



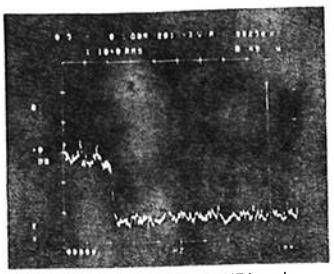
*Philips 20kHz distortion 0dB (−100dB base)*



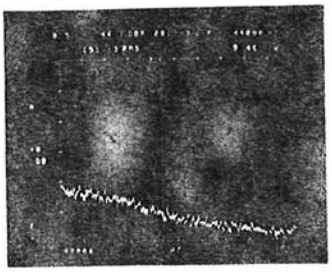
*Toshiba 20kHz distortion 0dB (—100dB base)*



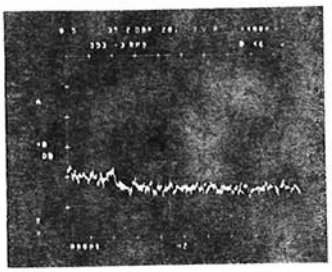
*Sony noise spectrum (−130dB base)*



*Hitachi noise spectrum (−127dB base)*



*Philips noise spectrum (−130dB base)*



*Toshiba noise spectrum (−130dB base)*

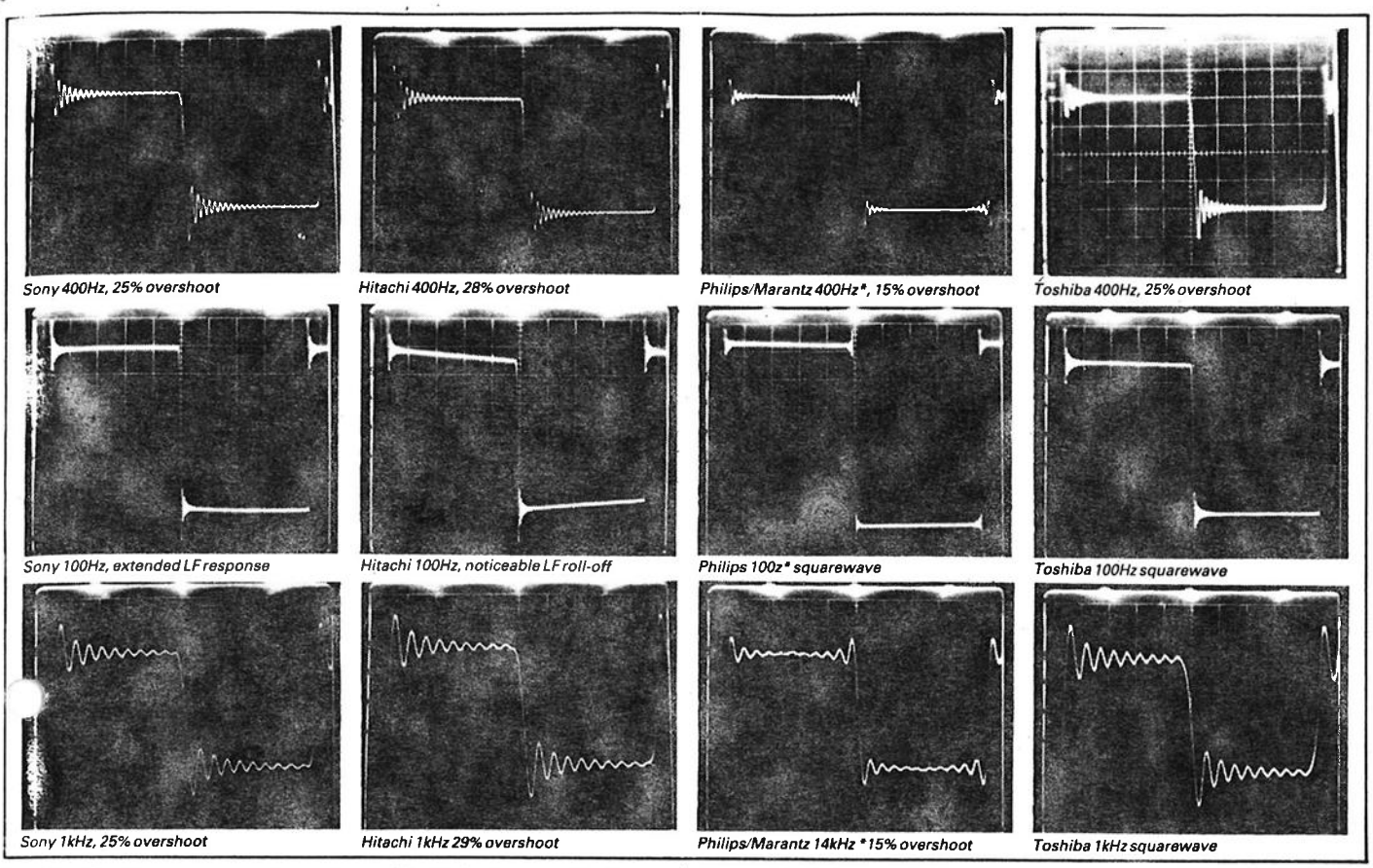
and in good systems it essentially stays at the background noise level. Somewhat limited by instrument noise levels, the swept, two-tone intermodulation distortion (70Hz difference product plotted in Fig. 6) shows good linearity and provides the otherwise missing information concerning the high frequency range. In general the distortion is no worse than at mid frequencies. In practice, however, the Philips gave rather poorer I/M results than the others.

Distortion spectrograms were taken at 1kHz, −30dB, and 20kHz, 0dB levels. For the Sony at 1kHz the harmonics can barely be separated from noise, the baseline of this graph being scaled at 130dB below peak level! For the Toshiba under the same conditions (longer noise averaging here gave a smoother baseline), several harmonics are visible at the appropriate horizontal marker intervals *eg*, 2nd, 5th and 7th. The ratio of such harmonics often changes with each alteration is signal level.

Noise analysis (spectrogams) showed some interesting differences. The slow Bessel roll-off of the Philips output filter is clearly shown, the output demonstrating a low incidence of spuriae, while in-band noise is also low. The Sony is similarly quiet in-band, with a couple of signals just poking through below 20Hz. The brickwall filter, however, is clearly in evidence, while the ussual 20kHz component is under the marker line at around −105dB, hardly of any real consequence. The Hitachi (early quiet samples) is rather noisier in-band, with clear spuriae at 44kHz, −76dB, and 88kHz, −66dB; these should be improved. It would appear that output amplifier noise is the Toshiba's problem, since the brickwall carrier can barely be seen at 20kHz. The in-band spuriae were also good here. For some reason the third Hitachi (production?) was marred by digital noise breakthrough and gave a noise reading around 10dB worse than that of the earlier samples.

The A-weighted readings for the good machines were particularly impressive for noise, at almost 100dB down, though CCIR/ARM gave somewhat poorer values. By any standards this confers an exemplary dynamic range. Using the latest samples, all the machines produced a healthy 2 volt output from a low source impedance, and all would be capable of driving most power amplifiers. De-emphasis operation was confirmed, and as expected, wow and flutter were entirely negligible. Considerable variation in track access speed, however, was noted — for a given track the Philips took 20 seconds as compared with just 2.5 for the Toshiba and 3.8 for the Sony. Slight mechanical whistling and clicking sounds were also audible from all the machines, with the Toshiba proving the quietest — in the case of the worst this was no greater than needle talk from a moving-coil pickup cartridge.

Utilising the programmed error test disc which carries an increasing dropout up to 2mm wide, the Philips/Marantz machines were judged the best. By the 13th track, the full 2mm gap present, their output was only occasionally and momentarily muted. The Hitachi was the poorest, giving rise to audible clicks and distortion from track seven onwards, and showing clear failure by tracks 8 & 9. The Toshiba showed slight fudging on 7-10, frequent clicks on 11 and severe impairment by 12, while the Sony survived a little longer, with momentary loss at 9, and periodic ticks at 10, these not too annoying but increasing by 12. On 13, serious audible dropout was apparent, with serious clicks. These results are only valid for an otherwise perfect disc, and while normal production discs will offer [illegible] dropout immunity, they will hopefully avoid 2mm wide h[illegible]les!



*Sony 400Hz, 25% overshoot* — *Hitachi 400Hz, 28% overshoot* — *Philips/Marantz 400Hz*, 15% overshoot* — *Toshiba 400Hz, 25% overshoot*

*Sony 100Hz, extended LF response* — *Hitachi 100Hz, noticeable LF roll-off* — *Philips 100z* squarewave* — *Toshiba 100Hz squarewave*

*Sony 1kHz, 25% overshoot* — *Hitachi 1kHz 29% overshoot* — *Philips/Marantz 14kHz *15% overshoot* — *Toshiba 1kHz squarewave*

Provided that the players and records are of satisfactory quality, the noises described above should never in practice be heard but a measure of the allowable margin is, nonetheless, still worth seeking in review. [Having used a machine at two recent hi-fi shows, I got two dropouts per weekend on well looked after discs — **Ed**]

Finally, the pulse response is shown in the squarewave performance photographs at 100Hz, 400Hz and 1kHz and these show nothing very remarkable. However, it is interesting to note that the results are certainly rather better than those of analogue pickup cartridges, particularly at low frequencies.

## Conclusions

With the project conclusions noted earlier, the following comments relate to the players themselves. At £430, or perhaps a little less, the Philips CD100/Marantz CD63 offers a very fine technical and subjective performance. Demonstrating a very neutral and consistent sound, it offers the highest error correction and is also the smallest yet made; it is, however, slightly slow on track seeking.

The more luxurious Marantz CD73, costing about £50 more, provides classy front loading with a rack compatible case and option for an extra remote control.

At the £500 level, the Sony represents a most attractive compact package of fine sound quality, with a fast transport and a delightful remote control. Random track selection, however, is impossible.

Although still an early model the Toshiba/Aurex showed considerable potential, and offered conventional styling with a fine sound and very fast transport.

We must reserve our judgment as regards the Hitachi. Various faults were present on all the samples, including the latest, imported in January of this year — possibly a premature launch? Similar reports of difficulties have come from other European sources and obviously the design cannot be recommended until the linearity fault has been proved to be corrected, this also true of the matching Denon machine. These problems aside, if asked the contentious question 'Would I buy a CD player?', the simple answer is 'Yes!'

## References

*Philips Technical Review*, Vol.40, 1982, No.6 and its appendices.
Sony *New Technical Theory For Service, CD Player CDP-101.*
Hitachi *DA-1000 service manual.*
Hitachi *Technical Promotional Material.*
B.A.Blesser — 'Digitisation of Audio', *JAES*, 26, 1978, pp.739-771.
Vanderkoy and Lipshitz — 'Resolution Below The Least Significant Bit In Digital Systems With Dither', Paper given at the 72nd AES convention, ref. 1930(D-1).

| Model | HITACHI/DENON | MARANTZ/PHILIPS | SONY | TOSHIBA AUREX† |
|---|---|---|---|---|
| Parameter | 20Hz 1kHz 20kHz | 20Hz 1kHz 20kHz | 20Hz 1kHz 20kHz | 20Hz 1kHz 20kHz |
| Frequency response | 20Hz-20kHz -0.5, -0.1dB | 20Hz-20kHz -0.5dB | 20Hz-20kHz -0.2, -0.8dB | 20Hz-20kHz -0.3, -0dB |
| Channel balance (dB) | 0.2 0.2 0 | Better than 0.05dB | 0.7 0.7 0.7 | 0 0.05 0.1 |
| Separation (dB)<br>Loaded 1k (unloaded) | 78.5 78.5 70*<br>(36) (68) (70) | 82 81 79<br>(94) (94) (87) | 89 89 84<br>(95) (95) (86) | 82 82.5 --<br>(83) (84) (80) |
| Phase difference L R | -- -5 -75 | -- 12 12 | -- -5 -76 | -- -4 -67 |
| Total Harmonic Distortion<br>(Beat tones) dB at 0dB | -53 -54 -49 | 100 -100 -90 | -102 -102 -80 | -90 -100 -77 |
| -10dB | -62 -62 -- | 94 -94 -- | -100 -98 -80 | -93 -87 -- |
| -20dB | -55 -56 -- | 85 -83 -- | -83 -90 -- | -82 -80 -- |
| -30dB | -50 -50 -- | -80 72 -- | -72 -80 -- | -70 -70 -- |
| -60dB | -- -44 -- | -- 45 -- | -- -45 -- | -- -44 -- |
| -80dB | -- 25 -- | -- 24 -- | -- -27 -- | -- -22 -- |
| Intermodulation (dB)<br>$f_2$-$f_1$ 70Hz at 0dB | -- 67 -50 | -- 83 -84 | -- -95 -90 | -- -80 -82 |
| 20dB | -- -50 -50 | -- 63 -64 | -- -75 -77 | -- -74 -78 |
| Signal Noise Ratio dB (ref. 0dB)<br>A-wtd. CCIR ARM | See spectrogram<br>94dBA 94.5 (84dBA, 86*) | See spectrogram<br>99dBA 92.5 | See spectrogram<br>99dBA 90.5 | See spectrogram<br>96dBA 89 |
| 20Hz-20kHz, 5Hz 80kHz | 95 76.5 | 99.5 96.2 | 97 94.2 | 95 85 |
| Output level/Source Z | 1.3V(fixed) 80 ohms<br>(1.95V*) | 2.0V 50 ohms | 1.9V 40 ohms | 2.1V (fixed) 100 ohms |
| De-emphasis | Satisfactory | -9.18dB 16kHz | Satisfactory | Satisfactory |
| Wow & Flutter (DIN pk. wtd) | 0.001%<br>7s | 0.001%<br>20s (Track 15 YEDS2) | 0.001%<br>3.8s | <0.001%<br>2.5s |
| Track access time | Fairly low | low | Low | Very low |
| Mechanical noise | Fair | Very good | Good | Fairly good |
| Error correction | See squarewave spectrograms at 100Hz, 400Hz and 1 kHz | | | |
| Pulse response | | | | |

*3rd sample
†Pre-production sample

**Note that the Philips digital filter gives time-reversed ringing on squarewave trailing edges!*

# CD MONITOR

## Angus McKenzie

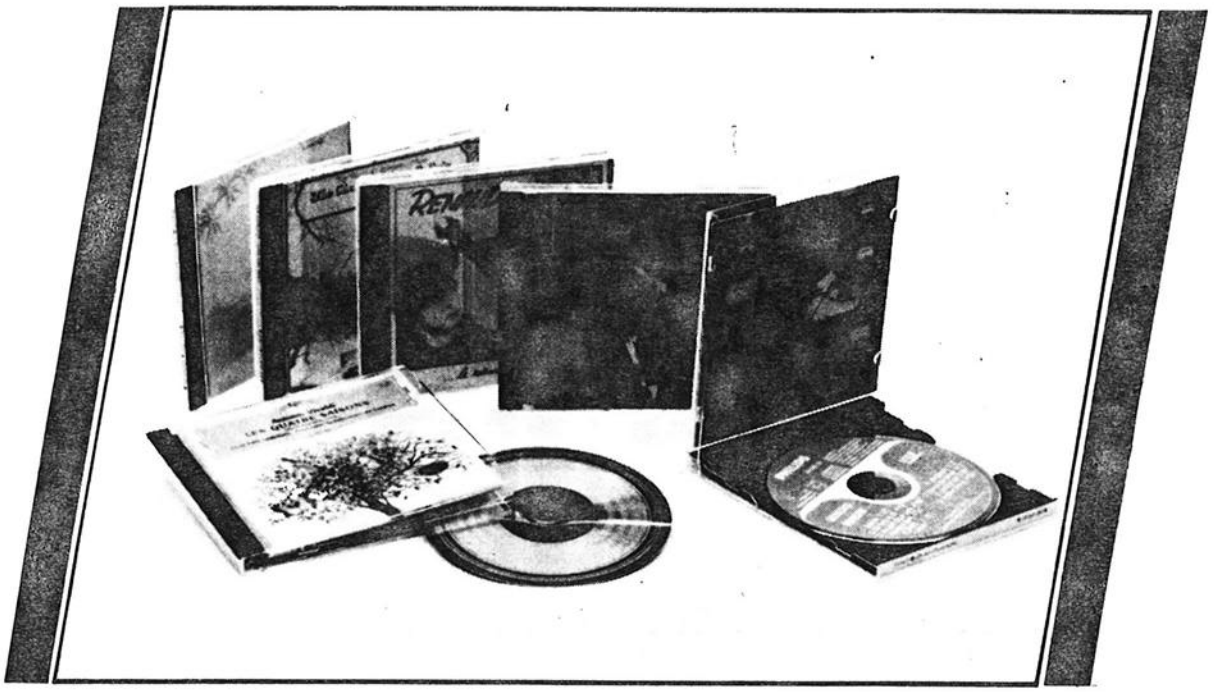
ON page 85 readers will have seen Cassette Monitor, in which I have been brutally frank about some of the dreadful sound quality that has been pushed out recently by some companies. Others at least have been trying to improve quality — most companies have admitted to me that Cassette Monitor has influenced them to try harder — but a few have totally ignored the column.

After a very pleasant evening entertaining the editor at my home, we both agreed that a Compact Disc Monitor along similar lines might serve two purposes. First, to assist readers in choosing some Compact Discs which are likely to please, and to warn them against others that, in our opinion, would be less satisfactory. And second, to point out to the record companies that there are many of us dedicated music lovers, who care about sound balance, who are getting fed up with many modern sound balance techniques. A particular *bete noir* of mine is currently a particular DG recording of Holst's *Planets Suite* (in any format). The Compact Disc version reveals more easily than LP rcord or cassette the thoroughly unnatural balance. Almost every critic that I have spoken to dislikes this recording — so how is it that such bad recordings are actually released?

This column will deal only with the reproduced sound quality, which should, in effect, be just the sound balance as originated in the studio, but which will obviously include any mix-downs from multi-track originals. It will also cover the differences between CDs made from analogue masters and digital ones. Perhaps we may find the odd faulty disc, but to begin with it is going to be very difficult apportioning the blame correctly. A typical example of this problem lies in the Japanese CBS/Sony issue number 38DC 11, Stravinsky *Petrushka*, New York Philharmonic/Mehta.

Approximately 1½ minutes after the beginning there are some timpani strikes which very audibly create some form of clipping/spit distortion, this phenomenon repeated several times on the disc. I have tried two samples, each on separate players from Philips and Sony. My colleagues and I have checked it on headphones, BBC LS5/8s, KEF 105.2s and Quad ESL-63s, with various amplifiers and preamps, and the distortion always remains audible. We spent some two hours examining the waveforms of the offending passage on a digital storage oscilloscope, triggering the picture gradually along the sound, and eventually managed to find an almost horizontal 0.8ms line at around −0.5V, which commenced with an extremely sharp corner.

The total peak-to-peak level of the music, however, was very much higher, showing that it was hardly likely to be the Compact Disc bits clipping, but clipping introduced in a microphone preamp, or on a multi-track digital recorder used for the original mastering. I am told by a friend who has the analogue disc equivalent that the same problem exists on it, so more care will have to be taken at sessions in future to avoid this type of occurance. So let's have a look at the stereo balance of some of the first Compact Discs that were made available to a few critics in November 1982.



### CBS/SONY (from Japan)

**Stravinsky; Petrushka, New York Philharmonic/Mehta (38DC 11).** This disc seems to have been time-coded only for the beginning of the first section, it being very difficult to find the other sections, since they are not coded. Depending upon the player, it may take up to a minute of fast forward searching to get to the fourth tableau. Whilst there was some welcome ambience, too many instruments, including higher and lower strings and brass, were positioned either hard left or right, although there was good woodwind positioning around the centre of the stage image. But see the introduction above for comments on timpani distortion. Not a bad disc, though, apart from this distortion, but rated **C+** because of several 'spits', etc.

**Beethoven 5th/Schubert 8th, Vienna Philharmonic/Maazel (38DC 1)** These performances were recorded in Japan when the orchestra was on tour, and sound rather better than most CBS releases. Double basses in the Beethoven were rather too close, and positioned on the extreme right, although the other strings were spread from left to right reasonably. The sound was fairly natural with a better than average perspective on woodwind, and the ambience was quite lifelike. Although, perhaps, the strings were slightly too forward in both works, the main problem with the Schubert is some extraordinary crackly digital hiss, particularly on the left channel, and a high pitched hum clearly audible in the quietest passages, which is disgraceful and results in a **C+** rating for this disc.

**Bruckner 4th, Bavarian Radio Orchestra/Kubelik (38DC 6).** This recording is superbly balanced with one of the best perspectives of any classical CD so far, although the hiss level is worse than average because the mikes were placed further back than usual. Rated **A-**, this disc gave me much pleasure. How marvellous it is to hear the french horn solo against the shimmering strings at the opening. I wish CBS could do more balances like this one. However, there are some audible edits at various places.

**Friday Night in San Francisco (35 DP 9).** This is a live recording made in San Francisco of three guitars, placed hard left and right and a very phasey and indeterminate centre. There is plenty of atmosphere, but ambience is

rather coloured. Rated **B**, and of specialist interest only.

**Billy Joel, The Stranger (35DP 2).** Although this is claimed to be 'stereo digital mastering' surely the original was analogue — I suspected hearing tape-originated modulation noise on some whistling. Even so, I thought this was quite a well balanced pop disc, with some very exciting sounds on it, and so it is rated **A**–.

## DG

**Brahms Violin Concerto, Berlin Philharmonic/Karajan/Anne-Sophie Mutter (400 064-2).** This recording is extremely bloated and massive, with a tendency to strident sounding strings and rather vague positioning of some of the instruments. The soloist is not only close-miked, but she is too far forward in front of the orchestra, and at times virtually as loud. Rated **B**– the recording has the merit of having an excellent S/N ratio, but remains tonally rather strident.

**Ravel concert, Orchestre de Paris/Barenboim (400 061-1).** At the beginning of *Bolero* I was rather astonished to hear passing traffic and other odd noises. Although there is some clanks 'off stage'. Although there is some wonderful music to enjoy here, the sound was rather over-miked, and surprisingly reverberant in a coloured way, particularly on climaxes. At worst the reproduction was messy, and just not natural; sometimes hard with detail missing — thus rated at **B**+. In the music there is a clear break before Danse generale in the 2nd *Daphnis and Chloe* suite, but the stored digitised beginning of this consistently came in late. At least this disc *was* programmed, unlike the CBS/Sony *Petrushka*, which was not, despite the programme notes implying that it had been.

**Mahler 1st Symphony, Chicago SO/Abbado (400/033/2).** Although multi-miked, and with not a particularly natural balance, the sound on this recording is fairly spectacular, reproducing with a staggering signal-to-noise ratio. Strings are a little over-wide, and woodwind slightly too close, yet the balance is valid, seeming much better than the average DG European balances. Stereo positioning is totally excellent, and this receives an **A**– rating. Unfortunately there is a strange background crackling at the start of the third movement.

**Mozart Mass in C minor, Berlin Philharmonic/Karajan (400 067/2).** Another multi-mike recording having over-wide strings, the sound is nevertheless most enjoyable with a good chorus/orchestral balance, and it is also very clean. Soloists are clear and only slightly forward. Signal to noise ratio is excellent, and this is rated **A**–.

**Mozart Piano Concertos K414/466, Rudolf Serkin/LSO/Abbado (400 068-2).** This reproduced with quite a good orchestral sound, but the piano seems to lack body and the middle frequencies are rather forward. The stereo imaging of the piano is slightly wide. There is much to enjoy, though, and this receives a **B**+ rating. I found Serkin's continual humming rather distracting.

**Brahms Symphony No.2, Los Angeles Phil/Giulini (400 066-2).** This disc lacks some openness, and some of the instrumental positioning is a little vague. Pizzicato basses did not seem to have the full sound that I would have expected, although that could be partly due to the performance itself. The sound coarsened a little on climaxes, and rated **B**+, it lacking that magic that would have put it into the A class.

**Mendelssohn/Bruch: Violin Concertos, Berlin Phil/Karajan/Anne-Sophie Mutter (400 031-2).** Whilst I prefer the sound here to that on the Brahms concerto, there are some strange bass thumps and rumbles which may be due to feet agitating a microphone stand somewhere — possibly the soloist's mike. The odd high note from the violin reproduces with what sounds like analogue tape modulation noise, but since this is digital, it is probably due to too close a mike pick-up, grossly emphasising bow/rosin noise, which I find disturbing. For this reason, I cannot rate it higher than **B**–.

**Vivaldi's Four Seasons, English Concert/Trevor Pinnock (400 045-2).** I tried this issue on Quad ESL-63s, BBC LS5/8s and KEF 105.2, and on no system could I get a completely uncoloured reproduction. The main solo violin is always too close and a little edgy, whereas the orchestra seems slightly confused, and sometimes slightly shrill. This could have been such a gorgeous sound if it had been recorded with an appropriate coincident mike technique in a warmer and more ambient surrounding. It's just not silky enough, and so rated **B**–, some rumble also being noticed in the background.

**Brahms/Schubert piano recital, Michelangeli (400 043-2).** If you want a natural sound of a fairly old piano in a concert hall type surrounding, this disc is not for you, for the elderly piano is reproduced with a very wide stereo image allowing one to hear every detail of the instrument very clearly as if you were rather too close to it. For me it is too intimate a balance, but nevertheless it is magnificent to hear possibly Michelangeli's best technical recording, and we should be grateful for it. Rated **B**, there is too much 'studio' and not enough concert hall.

**Stravinsky: Petrushka, LSO/Abbado (400 042-2).** I preferred this disc of Petrushka to the CBS one, for not only were distortion levels very good, but I did at least have access to all four tableaux and two further track entry points which is useful. The sound is multi-miked and rather close, ambience being lacking, thus producing a rather cold and slightly coloured sound. Rated **B**, perhaps we will see a better *Petrushka* in due course.

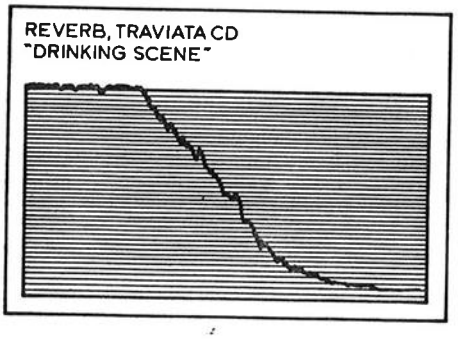
**Tchaikovsky/Dvorak String Serenades, Berlin Phil/Karajan (400 038-2)** I enjoyed this disc greatly, and I felt a warmth of string tone which is often missing from other issues — although ambience was slightly coloured, very high frequencies seemed to be lacking, and the presence region was slightly aggressive. Rated **A**–, I particularly enjoyed the Dvorak.

**Franck Symphony/Saint-Saens 'Le Rout', FNO / Bernstein (400 070-0)** This recording was made live at a concert in Paris in 1981. Despite a high pitched hum, clearly audible in most quiet passage (*eg* between first and second movements), and a rather phasey sound with some clammy reverberation, the music actually reproduces more naturally than seems usual with DG. Audience noise was hardly ever bothersome. At least no instruments were too close to mikes although the stereo is a little over-wide, but since I found it enjoyable it is certainly worth a **B** rating.

**Tchaikovsky: 1812 Overture/Capriccio Italien/Marche Slave, Chicago Symphony Orchestra/Barenboim (400 035-2).** This disc is a typical example of atrociously unmusical balancing — and it is worrying. A typical serious perspective error occurs shortly after the beginning of the *1812*, at a passage where a double bass player seems to let off hundreds of wasps from his bridge, which then fly out towards the listener. This absurdity is obviously caused by the engineer placing a microphone ludicrously close to one of the double basses. Brass instruments are miked in a 'we have ways of making you listen' technique. Overall this *1812* is rather vulgar and I could not enjoy it musically, although the bells and various explosions might sell the odd speaker system. However, I cannot rate this higher than **C**, *Capriccio italien* also sounding grossly over-miked.

## DECCA

**Verdi: La Traviata, Highlights, National Philharmonic Orchestra/Bonynge (400 057-2).** I started listening to the Act I Prelude and soon became aware (in the early quiet section) of our friendly Piccadilly Line Underground trains so characteristic of Kingsway Hall concerts! Even so, I quite enjoyed the Prelude, but oh — the drinking scene! Singers were rather too close, and low frequencies very phasey. What was more disturbing, however, is a cavernous acoustic with a rather long reverb time, also having some easily discernible multiple echoes. We pen charted these, and steps can be seen around −40dB and at −55dB approximately. I wonder if some artificial reverb has been used, for its characteristic is not very nice, giving the sound an empty cold background, and not the delightful warm acoustic with the very much better balance of EMI's recent 'Traviata'. Distortion was minimal, though, and there was a lot to enjoy, so I end up by rating this **B**– but wishing it could have been much better.




**Bela Bartok: Concerto for Orchestra/Dance Suite, Chicago Symphony Orchestra/Solti (400 052-2).** Although this issue sounds rather better than many other recent Deccas, I still found the string tone rather vicious, and many instruments somewhat phasily reproduced. There is, though, some nice warm ambience here, but I missed the sense of realism, the sound seeming faked-up by Decca's mike technique. Many people like this type of artificially enhanced sound, and ▶

since distortion is very low, and S/N is good, this CD certainly merits B+.

**Mantovani's Golden Hits (London 800 085-2).** It is fascinating to see how many evils the old pop, crackle and rumble, and tracking distortion of old LPs covered up, for I anticipated that I might enjoy this album but ended up hating it. One can easily hear various lurking musicians sitting around what seems a hot and smelly studio bathed partly in coloured studio acoustic and partly in a nasty artificial reverberation. Instead of Mantovani's strings seeming sweet with the brilliant musical tricks which achieved his famous string tone, they evinced violent reactions from everyone, including my secretary. What a total waste of a CD, and how it proves my point about opening windows and letting muck fly in! Rated D, for we all heard hum and noise to add to the disappointment.

**Camel, The Single Factors (800 081-2).** Some will think me slightly irrational if I admit to disliking this for very inadequate use of a stereo sound stage, everything seeming left, right, or centre as if the engineer couldn't find out how to produce any other positions. I know it's personal, but I cannot stand singers, percussion and rhythm section all being pan-potted precisely dead-centre. I rate this C+, although signal-to-noise ratio was quite good.

*Decca will have a number of classicial titles available for the CD launch, but these unfortunately had not arrived in time for review.*

## PHILIPS

**Art Blakey and the Jazz Messengers (800 034-2).** This disc is very clearly in the demonstration class, distortion levels being incredibly low, and the balance in general being very clear indeed, except for a slightly muddy bass sound. Some listeners may find the overall sound on the dead side, but this is highly personal. In the lab, we all found the disc very exciting indeed, and recommend it highly for showing the potential of the medium — thus rated A+.

**Genesis, Abacab (800 044-2).** It is extremely difficult to critisise a disc such as this, which is a typical artificial electronic creation of a fairly well produced rock sound. In attempting to judge it as sound rather than as a production, I was impressed with the backing and with the signal-to-noise ratio, and its clarity despite it being an analogue original. But why do the engineers give Phil Collins such a castrated sound, failing to produce any body to his voice. I think it fair to give this a B+ rating.

**Elton John, Jump Up (800 037-2).** Whilst Elton John's voice reproduces very well, I found that high frequencies on the backing were obsessively hard and over-bright, whilst there was frequently a slight lack of bass, even when I played back at, for me, quite a deafening level. On some of the tracks, hiss became all too noticeable, and whilst the overall sound was far superior to a normal disc, it clearly shows that the best CDs are not made from analogue originals, and so B−.

**Dire Straits, Love Over Gold (Vertigo 800 [illegible]-2).** This rock album reproduces much more clearly than its analogue counterpart, but whilst distortion is relatively low and sounds are quite clean, I can only rate it C+ because of analogue tape hiss, despite the master having been at 30 in/s.

**Rush, Moving Pictures (Mercury 800 048-[illegible]).** I admit to being a fuddy-duddy, and I could not bear some of the distortion intentionally

introduced on electric guitar for example, but it must be said that this is an extremely well engineered mix-down of a very fine original recording. Tape hiss once again rears its head in the rare moments when the music is not incredibly loud. I am sure rock fans will love it, but I only rate it B−.

**Richard Strauss: Also Sprach Zarathustra, Boston Symphony Orchestra/Ozawa (400 072-2).** Despite this recording being multi-miked, the impact is far cleaner than many other CD orchestral recordings. The famous opening is magnificent, despite cymbals being a little too far forward, the organ thundering away magnificently. It was pleasant to hear more coherent ambience than usual, but I wish that Philips' engineers could learn to do better digital editing, for I heard a very obvious edit a few minutes after the beginning. Nevertheless, rated A and recommended for demonstration.

**Mozart Piano Concertos K450/K467, ASM/ Marriner/Brendel (400 018-2).** With this disc, there seems to be a serious perspective problem, for whilst the orchestra reproduces extremely well, with some delightfully warm ambience which helps the string tone, the strings are rather too wide. The piano is rather far forward, and this jolts one on its first entry in K450. Close miking has unfortunately greatly emphasised the top end of the piano, but in addition the piano mike's contribution is too great, and also overwide. If the piano had been better balanced, this disc could almost have been A− but as it stands it is just a B. K467 fares better, with the treble end of the keyboard not quite so aggressive, and with some delightful woodwind.

## POLYDOR

**Abba, The Visitor (800 011-2).** Whether you like Abba or not, I don't think you could deny, when you hear this disc, that the recorded sound is almost miraculously clear and clean, as well as being very well balanced indeed. I found myself impressed with the clear percussion which was not too far forward, the sound never becoming hard. Bass was just about right in level for me, and the voice surprisingly natural, and thus I rate this A+, for gone is the noise that is too obtrusive on so many analogue originals.

**Jarre, Magnetic Fields (800 024-2).** Jarre's latest of three albums to be transferred to CD, this has a far better dynamic range than has *Oxygene* for example. I was fascinated to see how he made music out of a goods train passing, whilst the whole album is very typical of his style. It sounds that much cleaner, which makes me wonder if the earlier analogue masters have perhaps lost some of their original magic, because they had been played a lot (*Oxygene* on CD was both noisy and grittier than I had remembered). Rated B+, *Magnetic Fields* is a must for Jarre enthusiasts.

**James Last, Tango (800 016-2).** Whether you regard this as musical wallpaper, or as music to dance to, serious hi-fi enthusiasts will not, I suspect, want to use this disc as a demonstration one. The rhythm section is far too forward, whilst the strings are at the other end of the platform at Leicester Square on the Northern Line. Rated D I can't really see the point of having this on a CD.

**Visage, The Anvil (800 022-2).** For about the first minute of playing back this disc, a colleague and I began to wonder what point there was in putting a mono recording on CD — but then we started hearing various lurking pan-potted sounds coming from other than centre. It may be somebody's strange philosophy to use a stereo sound stage in this weird manner, but it's not mine, and so I rate this boring sound D.

**Fame, The Original Soundtrack (800 034-2).** Considering this disc was probably made from analogue mastering, much of the sound was remarkably good, although occasionally instruments such as the high-hat seemed over-equalised; I suspect also a degree of HF tape compression. Certainly worthy of B+, this one is worth trying.

## CONCLUSION

Whilst most of the Compact Discs in this review were very impressive for the first few seconds of auditioning, it will be seen from the above comments that too many of them were frankly unmusical. The very absence of background noise and distortion tends to draw the listener's attention all too readily to balancing problems. After listening to so many, my colleagues and I are agreed that it is important to listen to them at the right level, especially so when one wants to concentrate on the music itself.

I was surprised to find instances in which problems other than sound balance cropped up, and we investigated further the Mantovani hum problem, which typifies the lack of care taken in the production stage. We set a peak reading meter to the maximum program playback level on 'Greensleeves' and then analysed with 3Hz bandwidth the 50, 100, 150, 200 and 250Hz hum components. Just after the track was faded up, and before any low frequency instruments began playing, there was a clear 1.5 seconds or so in which hum was clearly audible. Our analysis revealed the 50Hz signal to be at −40dB, and the 150Hz component to be at −60dB, the 250Hz one also being discernible. These hum levels are disgracefully bad, and one might expect them perhaps from a cheap and nasty ten-year-old music-centre, but not from a Compact Disc— or even a decent analogue master tape, even if this is fifteen years old. It would seem that Decca either do not have a steep hum-rejection notch filter, or just didn't bother. We also noted hum in the Bernstein Franck D Minor symphony on DG, and on Schubert's 8th on CBS Sony.

I am not trying to be destructively critical here, but constructively so, in the hope that much more care is taken in future both in sound balance and re-mastering. I am being stricter in ratings, and a C+ for a CD could well be a B or higher on a cassette, as faults noticeable on CD could be obscured on other media. I hope that I will be possible to recommend a higher proportion of CDs in future, and my policy, as agreed with the editor, will be to pick out the very best discs, and a few particularly poor ones, to emphasise differences.

HFN&RR March 1983

# Japan, Technics and the Compact Disc

## Part 2

**Martin Colloms, back from a visit to Matsushita in Osaka, reports on developments at Technics**

### Digital cassette recorders?

Staying on the digital or PCM track, I was shown two examples of lab-only working 'machines of the future.' One was a digital compact cassette recorder designed along the lines of others shown already by such manufacturers as Sony and JVC. The Technics one uses a 12-track ferrite head with a very narrow 0.3 micron gap, plus special thin-film metal tape (digital Ångrom running at 9.5cm/s) working to CD standards. 16 bit linear quantisation was being employed at 44.1kHz sampling. This format promises the capability of direct-dubbing of disc to tape, although the CD software producers are seeking to prevent this by the use of copy protection codes.

In my opinion, however, the domestic digital cassette player is a long way off, perhaps as much as four or five years distant. Technics' research has indicated that present cassette mechanism housings are inadequate to the rigours of digital working, and they were discussing possible revisions to the shell as well as the guides in order to improve head contact and phase consistency. Manufacturers conducting digital cassette research at present are involved in mutual discussions as to a possible 'standard', but until they have learned 'how to do it', a standard can't possibly be set; and until the latter is established, there can be no domestic production.

So while the chip technology will not prove too difficult (largely borrowed from existing CD and PCM video adaptor practice), recording and retrieving the digitalised audio with compact cassette tape will remain very hard, due to astronomical tape head costs. With vastly better 'digital' tape, plus multi-track working, and different running speeds, it would seem logical to redesign the compact cassette specifically for digital work, since the question of compatibility with an analogue cassette deck would not arise except in terms of manufacturing convenience.

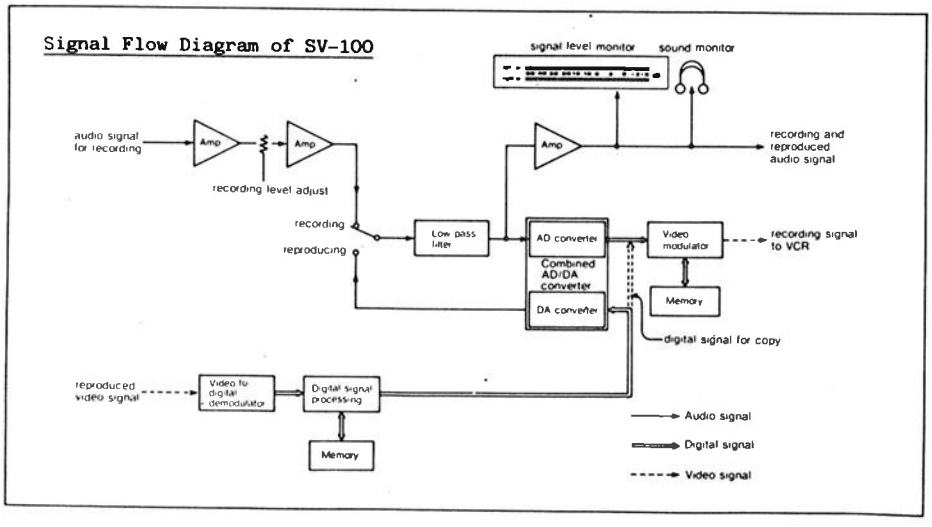
In a lighthearted (?) vein I also got to see a Technics digital microcassette recorder, this a near fictional device. It failed to work on first try, generating appalling distortion, but we were asked to give it a second chance. Accordingly we tried it after lunch, and it did succeed second time around in playing music of sorts. In my view this is not a serious venture, and it is most unlikely to be marketed for a considerable period of time. Again, it used a special Technics Ångrom tape, with twelve parallel tracks running at 4.8 cm/s: the maximum two-way playing time is 45 minutes. The sampling frequency chosen of 32kHz imposes a 15kHz upper frequency response limit, while an 85dB dynamic range is claimed with 0.01% or less distortion, this achieved with 8 bit coding using a heavily non-linear transfer characteristic. The non-linear function is, of course, generated digitally, and in theory should work rather better than the analogue equivalents. But conversely, when things go wrong at this high information density level, the failure in audio terms is not one of simple dropout; rather it results in catastrophic failure, revealed as gross distortion.

Both these 'prototypes' look clean enough in a photo [see P.41], but in practice they were connected by a substantial umbilical to a massive rack of digital hardware. In fact their cases contained only essentials of their mechanisms, with separate units housing the actual processors.

Returning to the realities of domestic digital recording, Technics' SV-P100 VHS video deck continues in production, but is now joined by the SV-100 digital audio processor, which sells in Japan at the remarkably low price of Y150,000 or around £350. As with Sony's PCM-F1, the SV-100 adds digital record/replay to any domestic VCR. The Sony is a 16-bit machine, but the Technics design sticks to the EIAJ standard used in the SVP-100, namely 14-bits linear. Total harmonic distortion is specified at 0.01% at full modulation, with the usual 86dB dynamic range. Claimed to be the world's lightest, the processor weighs 2.9kg, with the separate mains power pack at 2-3kg. The attractively low price has been achieved mainly through the use of a new digital converter IC which operates both in A/D and D/A modes like the Hitachi design (see block diagram of signal flow). Possessing a one hour recording capacity on in-built rechargeable batteries, the SV-100 processor is also joined by a new lightweight Panasonic VCR, the NV-100, to make a competitively priced portable digital recording system. Supplies of the PCM processor are expected soon in the UK and PAL form, with an estimated price of around £500 or so. (We hope to review the system when it is available.)

Of all the demonstrations that my hosts, Technics, laid on for me, the most successful was undoubtedly a small recording session with the domestic PCM recording system, which allowed comparison of the replay with the original. In a relatively informal arrangement, Technics had invited a charming Japanese jazz vocalist Keiko Tani to sing, accompanied by Mr Yamashiro on the piano. This session took place in a Technics custom-built studio/listening room with replay monitoring on the large honeycomb-diaphragm SB-M1 speakers. Using a two-microphone technique, (plus a B&K omni on the piano), a very high standard of sound replay was demonstrated, with effortless dynamics and great subtlety of fine tonal shading. The high quality of both the PCM processor and the speakers was amply demonstrated.

The listening room was designed by one Shinuchiro Ishili to represent a reproducable standard, and it offers some acoustic adjustability via the use of sliding panel screens. The rear wall behind the speaker is essentially reflective, and the main design target of the room was to provide a uniform reverberation time over the whole frequency range, the latter rather wider than the classic 125Hz to 8kHz span normally adopted for architectural acoustics. Specified for 20Hz to 20kHz in third octave bands, the reverberation time for this tapered room is 0.4 seconds from 100Hz upwards, with some minor ripples between 0.3 and 0.4 seconds from 20Hz to 100Hz. The overall result, though, is so uniform that quite accurate loudspeaker response measurements could be undertaken in it, the room employing an



appropriate half and half mix of anechoic and reverberant chamber constructional methods.

As its designer correctly points out in his AES paper (1887 B-4 72nd convention, for those interested), a conventional listening room has a reverberation time complicated by standing wave effects, which is markedly and erratically increased at low frequencies. For example, values of around one second are not uncommon at 50Hz. In his room the designer has audibly and measurably solved this problem, but one is still left with a discrepancy in sound between normal domestic conditions of loudspeaker use and this perfect laboratory test room. So a speaker with excessive low bass output in a normal room might sound quite dry and correct in the special room. This problem of specifying a standard room remains a difficult one for all speaker designers.

To close this digital discussion, Technics are also involved in the professional side of PCM recording, and their linear path 4-track recorder is now finding its way into some Japanese studios. Off-tape monitoring is possible during recording, the record head a thin-film type and the replay head based on magneto-resistive principles. Running conventional 10½in. reels of ¼in. tape at 38cm/s, the replay sound quality of this machine was exemplary — some of the best digital I have yet heard. With 16-bit linear coding and equalisation, a 50.44kHz sampling rate is used, offering a dynamic range of greater than 90dB, and total harmonic distortion (at +4dB) of 0.05% or less all the way from 20Hz to 20kHz. No lightweight, this trolley-mounted machine weighed 353lbs, and the remote control itself accounts for some 57lbs! A matching editing console was also demonstrated, this a two-channel device with variable cross-fade times and up to 8 seconds of pre-monitor. Editing accuracy was high at a quoted 120$\mu$s. A digital mixer, 8 in to 2 channels, together with a digital preview unit, completes the professional equipment line-up. This press trip to Japan, was, as you may have guessed, courtesy of the Technics division of Matsushita. Besides their equipment already mentioned, I was shown many of that company's new developments. These ranged from prototypes of devices yet to be developed for production to new audio models, some analogue, some digital. We also saw some of their recently installed production facilities, which are highly automated. Typically each morning's seminar began with a sophisticated audio/visual presentation, employing as many as 10 synchronised projectors at a time. Sound levels were pretty high, but clean and if you were not quite awake before, as a result of the previous night's hospitality, you certainly were after one of these sessions!

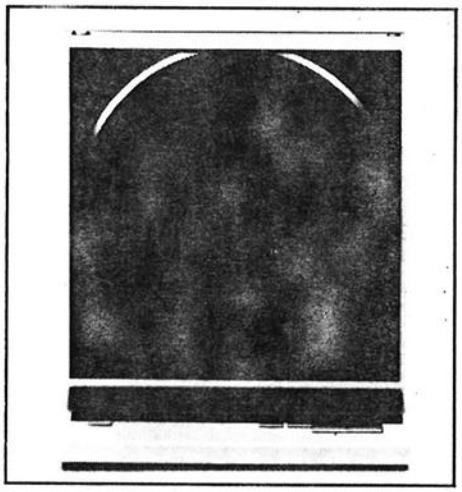
Technics engineers' were particularly proud of an amplifier circuit which used a microprocessor to monitor and control the operating conditions of the output stage. This can considerably reduce the distortion effects resulting from bias changes due to temperature alterations in transistors during musical transients. Using a distortion cancellation technique similar to Quad's 'null test', the Technics engineer presenting the amplifier was able to show that in normal amplifiers small but prolonged changes in crossover distortion lasting several seconds follow heavy power transients. The microprocessor control system was seen to visually eliminate the resulting distortion, with complex tracking of temperature, load, and power all taken into account. No specific evidence of improved sound quality was given though. Two models incorporate this computer drive, the SU-V 505 (60W/ch) and the SU-V 303 (40W/ch).

On the audiophile front we were shown a new preamplifier in the A3 series. Despite the advantages in semi conductor technology, Technics have chosen to install their very costly SH-305MC amorphous core step-up transformer instead of a solid-state headamp. These products were considered by Technics to be in the same league as the Sony Esprits. If partnered by the SE-A3 Mk2 power amp, the estimated combination price is around one half that quoted for the Esprit in the UK. Alone, £500 was suggested for the 305MC-equipped preamp.

Further research is continuing on costly audiophile tuners, these employing multi-gang passive or mechanical tuning sections rather than the varicap or semi-conductor diode capacitors used in the majority of digitally-synthesising tuners. We were shown a costly silver-plated, 10-gang tuning capacitor where the drive shaft had been increased to 9mm in diameter to maintain mechanical stability, this a remarkable component that will be used for a new top-line tuner presently under development.

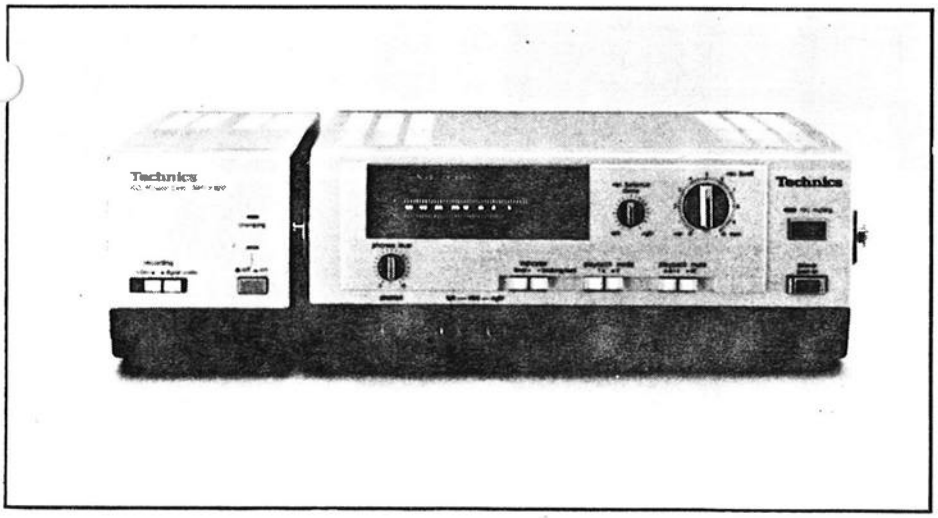
Some confusion was generated during the presentation of a new tuner, the ST-S505, which was apparently described as DC-coupled, this also being indicated by a prominently displayed label on the front panel. However, when questioned closely on this matter — an important point since similar claims have been made in the past concerning pre and power amplifiers — it transpired that the audio output of the tuner was not in fact DC-coupled but much of the internal circuitry was. It was claimed that this leads to a considerable improvement in the low frequency response of the system, leading to better stereo separation and distortion. A particular detail I noticed was a spectrogram of the output noise of this 16-station synthesised tuner, where the absence of spurious audio band whistles was immediately obvious, in marked contrast to many of its competitors. The moderately-priced STR-S505 also has a microprocessor for automatic switching between wide or narrow IF bandwidth according to the reception conditions and the proximity of adjacent interfering signals. Amongst its remarkable specifications were a mid-band distortion figure of 0.05%, a separation of 60dB, and a wide 5Hz to 18kHz, +0.2 — 0.5dB frequency response. Technics suggest that it is ideal for taping live broadcasts on a digital recording system!

The turntable and cartridge division appears to be maintaining the great impetus and market lead generated by Technics in-house direct-drive motor technology, with the recent slim-line parallel-tracking range going from strength to strength, and giving rise to numerous imitators. The SL5 low-cost model has been joined by the SL-V5



designed specifically for vertical orientation. All these turntables (SL3, 6, 7, 10, etc), as well as others in the current range, use the Technics T4P cartridge system, a simple plug-in arrangement that is secured by a single bolt and with all alignment problems taken care of. It is now an accepted industry standard, and many firms have joined Technics in making cartridges in this form, including Stanton, Pickering, Shure, Audio Technica, and Ortofon. One fool-proof advantage is that a with a defined head mass, the correct tracking force is automatically applied upon installation.

A new version of the ruby ball bearing tonearm, the EPA100, was also shown. Now called the Mk II, numerous refinements have been incorporated, including a boronised titanium tube for the main beam and a boron-reinforced detachable headshell. Effective mass is quoted as 15g, and we saw another version for T4P cartridge mounting whose mass was estimated at some 50% lower. To go with these aims, two new cartridges have been developed, one the Mk II verson of the 305MC (a long established moving coil model). A year or so back, Technics attained new heights in moving-magnet cartridge design with their EPC100 MkII and its derivative the famous EPC205IIIL, and when questioned on their current attitude to moving-coil development, they admitted that



their sympathy lay with the moving-magnet principle, particularly as regards the new wide-bandwidth forms, though market demands also dictated improved versions of their moving-coil type.

Certainly their trump card developments in technology have been reserved for their finest moving-magnet model yet, which is not yet in production but will be called the EPC 100 Mk IV. Still further reductions in tip mass to astonishingly low levels are claimed, with a frequency response extending to beyond 80kHz to within 4dB, and the output just 2dB down at 125kHz. The high frequency test record had to be run at 2.5 times normal speed (at 83.33 rpm) to generate this graph, although in a real sense it is invalid, since the wavelength of the maximum 125kHz recorded in the groove is actually that of the original 50kHz recorded at 33⅓rpm.

In addition to using a very small stylus stone and a thin-wall boronised tapered cantilever, further improvements in the fixed coil system and associated poles have extended the electrical frequency response. The final touch is the new stylus profile called by Technics 'linear elliptical', whose specified dimensions of 4 x 60$\mu$m correspond closely to those of Van den Hul's stylus. The graphs illustrate the loss in high frequency response from outer to inner grooves with a normal elliptical stylus 8 x 8$\mu$m tip radius, as well as for the new tip. The linear tip shows a 2dB drop at 20kHz (comparing outer with inner groove radii outputs) while a normal elliptical gave a 5dB

loss. At present we all live happily with this change in frequency response during the progress through a record side! The linear tip has a remarkable geometry whereby the contact area is thinned in depth as well as in profile so that the effective contact radii do not change appreciably as the tip wears, and it was suggested that this tip gave two to three times the life of a normal stylus. The electron microscope pictures clearly show the unusual grind of this stylus as well as its very small overall size, but Technics would not reveal exactly how it was made; I would speculate that the depth profiling was achieved by laser machining after the overall grinding and shaping. Such precision work will not come cheaply!

Before leaving analogue disc players, the current progress of the lengendary SP10 direct-drive motor unit is worth reviewing. Now in Mk II form, it remains in context a competitively priced item. The Mk II is still in production, and has sold over 3,000 units to studios and broadcast organisations in some 30 countries, including large quantities to our own BBC. The new Mk III version retains the three speed options (33, 45 and 78 rpm) but now has full synthesiser speed control. A massive 16kg-cm of starting torque is available, this required to bring the heavy composite copper and aluminium platter to speed quickly. Weighing 10kg with a 1.1 ton-cm movement of inertia, the platter start-up time to 33⅓ rpm is nonetheless an amazing 0.25 of a second, while an extraordinarily low figure is claimed for rumble (test method unspecified) of no less than 92dB DIN B weighted. However, it still requires a good foundation, and no matching isolation system is available of adequate performance.

In general, Japanese turntable designs, including those from Technics, have comparatively poor isolation from external acoustic and vibrational energy. Queried on this point, Technics engineers stated that while the matter had been considered, it was not thought to be very important in terms of their overall market. Nor were matters of turntable coloration high on their list of design problems as long as their partial and none-too-effective solutions lay in low resonance compounds and high mass. The classic spring-suspended subchassis principle so successfully used by UK and other European producers is considered impractical. In a sense, they have therefore chosen to ignore the low coloration/high information retrieval sector of the market, the SP10 series succeeding in limited domestic circles more by brute force than skilled mechanico-acoustic system design. It was admitted also that even with their prestigious player system based on the SP10, the sound would be improved with the acrylic lid discarded. This is because it is insufficiently isolated from the tonearm platform and contributes significant coloration.

I have previously mentioned experimental Ångrom cassette tapes in connection with the prototype digital recorders. There is yet another version of this type designed for analogue compact cassette decks called Ångrom DU. This new double-layer tape uses a conventional coating coupled with a vapour-deposited pure cobalt thin-film surface. With a dbx-equipped cassette deck, the dynamic range is claimed to easily exceed 16 bit digital ($CrO_2$ equivalent dbx dynamic range claimed at 110dB). A 20Hz to 30kHz frequency range was also claimed, though it was conceded that not only were special record and replay heads required, necessitating a three head mechanism, but also new bias and/or equalisation settings were needed on record. Replay was to the current chromium standard, and in a sense this tape combines the best of conventional and metal types. Available in Japan early this year, it may be on the UK market by autumn.

Technics also noted that tape heads would probably have to be built using their new amorphous core material with very narrow gaps, particularly for replay. On the subject of cassette recorders, their new machines were also demonstrated, and for me, the sound was certainly not to PCM standard. The stereo sounded phasey and some muddling of detail was noticeable, but conversely the dynamic range was very good.

Seen previously in prototype form, the dbx-equipped personal cassette player dubbed the 'Way' has now been released in Japan, but is expected to be marketed in the UK. A particular achievement was the design of a dbx integrated circuit capable of low voltage operation, down to a 3V battery supply end-point of just 1.4 volts). In dynamic range terms the dbx Way is certainly of hi-fi quality with a 90dB-plus dynamic range (dbx replay), a 40Hz to 14kHz frequency range, and a hyperbolic contour replay head for cleaner bass.

Questioned on the multiplicity of noise reduction systems offered on their top-line cassette deck — Dolby-B, Dolby-C, dbx and dbx disc replay, they explained in good humour that their machine represented their best technology yet called the 'ED' system or 'End of Discussion' on noise reduction! In fact, remembering some press trips with other Japanese companies, it was clear that Technics on this occasion at least had sufficient confidence in their stature to answer difficult questions in a frank and open manner, this in marked contrast to the somewhat evasive replies given to journalists in previous years.

Before leaving the subject of cassette players and recorders, their production numbers can be used to give some idea of the massive scale of the Matsushita operation. Taking these two items alone, both hi-fi and portables under Technics, Panasonic, and National brands, the monthly output is ⅓ million units, these produced in seven factories, and with 70% going for export to 130 countries.

On the loudspeakers front Technics have developed two new monitor systems, the SB-MI four-way floor-standing unit, and the SM-M2 three-way stand-mounted system. UK sale is unlikely for these models which retail in their homeland at around £1,800 and £1,000 a pair respectively. Both use flat disc diaphragms throughout, with Technics' own aluminium foil honeycomb-core diaphragms — these handmade on a small production line. The new 28mm tweeters used are exceptions and employ natural mica for the diaphragm skins. I made one personal objection — their protection grille is virtually an exact copy of the B&K microphone grille design. Surely Technics could have come up with their own interpretation?

Looking briefly at details of the SB-M2, the reflex-loaded bass unit is 380mm in diameter and is energised by a massive 3.0kg, 1.48 Tesla magnet on a 75mm diameter motor. A high 92dB/W system sensitivity results, and 'pistonic' break-up free operation is claimed up to 2.0kHz. When I reviewed one of the earlier flat diaphram systems from Technics, the SB-10, I noted that the bass driver had impaired resistance to rocking modes (the Japanese engineers described this contrarily as 'rolling'). A new spider (rear cone suspension or damper) has since been developed consisting of four cantilevered box sections rather than the usual circumferentially corrugated disc. Pressing on the driver diaphragms of various examples fitted with both types of spider showed a great improvement in rocking resistance with the new version. Overall linearity has been improved this way.

The SB-M2 system crosses over at 750Hz to a 200mm honeycomb midrange unit, which is itself filtered at 4kHz for smooth transfer to the 28mm tweeter. The flat diaphrams naturally endow the system with an intrinsically flat linear phase response, so allowing a simple flat baffle cabinet design. However, the overall system is not linear phase since the computer-designed crossover is essentially of 12dB/octave slope, with the phase reversed at each driver interchange; but the overall phase response is pretty smooth, nonetheless. Weighing 50kg, the speaker's internal volume is estimated at 130 litres with an overall quoted frequency range of 27Hz to 38kHz. After all the ballyhoo from Technics in previous years concerning the importance of an ultra wide

bandwidth, and their use of a 100kHz-capable leaf tweeter (which in practice was only satisfactory as a super tweeter), it was a relief to see a return to normality in this department.

Computer-aided design is used exclusively for speaker research, finite-element analysis of cabinet structural vibrations, driver simulation, and crossover system response sythesis and alignment. On the measurement side a new anechoic chamber has been equipped with a Technics custom-designed audio processor which uses both digital and analogue analysers. Employing an array of microphones on 12 data channels, it can perform a pretty comprehensive test program in under one minute, an operation which would ordinarily take about an hour to achieve. What would a speaker reviewer give for such a facility? Axial, 30°, 45°, 60° lateral, +15° and −15° vertical frequency responses are all taken, in addition to 2nd and 3rd harmonic distortion plus phase response and impedance.

Shown the speaker production facilities, I found the degree of automation used impressive. The contribution made by the Matsushita group is equally amazing — they have drivers for other manufacturers such as Pioneer, Sansui, and Trio and produce a staggering 40% of all Japanese drive units made. Overall, around 60 million units a year are manufactured, although not many are strictly hi-fi types. One facility I had never seen before was an automatic cabinet manufacturing machine. In virtually one unit and without human intervention, veneered precut timber was loaded by suction into a V-groove cutting mill, after which the grooved panels were glued and folded up to previously located front and rear panels to make a complete assembled cabinet: total time of under one minute. Completed enclosures moved off on a conveyer system to the driver installation stage which was still done by hand — but one wonders for how long.

In the component stereo field, Technics engineers were clearly very proud of their new stereo 33-band ⅓ octave equaliser, model SH-8065. This has an unusually wide control range overall from 14Hz to 30kHz. The ±12dB amplitude range may be expanded to ±3dB for greater sensitivity, and great care has been taken to ensure minimal degradation in sound quality. While it is specified for use by the professional and advanced amateur, it is clear that one potential use will be for the so-called equalisation of a domestic hi-fi installation. To this end, a matching acoustic analyser (SH-8000) has been produced which comprises a ⅓ octave warble tone generator, 20Hz to 20kHz, and a calibrated sound level meter plus measuring microphone. With the latter, one is assumed to equalise one's audio system using the SH-8065. While I feel the analyser is a most useful low-cost measuring unit, equalisation is a very difficult and time-consuming procedure, probably best performed with a real-time parallel band ⅓ octave analyser such as the Klark Technik or Ivie.

In any case, the question arises as to whether room sound equalisation is desirable, since the main room response errors occur in the time or reverberation domain, a region inaccessible to the normal equaliser. In addition, when different equalisations are allocated to each stereo channel, phase and amplitude differences with frequency are imposed on the first-arriving or direct sounds from the speakers, seriously damaging the stereo effect. Technics themselves unwittingly gave convincing proof of this in their own demonstration of the equaliser. In an appropriate context, however, such as signal tailoring and monitoring equalisation, etc., the equaliser undoubtedly represents a significant contribution.

During our visit we were ably assisted by Mr Ken Kuno of the export division, who gave us some interesting background on the company and its attitudes to newly induced engineering and management graduates. On entering the company, 'apprentices' spend several months on the production lines as an assembly worker, to better appreciate life at this level and to retain some future concern for the welfare of production staff. The company's founder Mr Konosuke Matsushita believes strongly in good publicity and the power of advertising a good product, so to gain an insight into customer relations new recruits are also required to spend some time as general assistants in retail outlets. Ken Kuno found this experience valuable, if at times a little dangerous — at one stage he found himself rigging TV aerials on fragile Japanese tiled roofs without any prior training!

Despite the hi-fi/audio component recession, one cannot help but be impressed by the sheer size and prosperity of the Japanese economy at the consumer level. Their cities appear to be filled with well-dressed, free-spending citizens, with consumer sales running at a dizzy rate. Seeing at first hand the power and scale of their home market it is much easier to understand how effortlessly the Japanese have come to dominate so many markets in so many fields, and undoubtedly, judging by the level of investment in research and industry in general, there is yet more to come.

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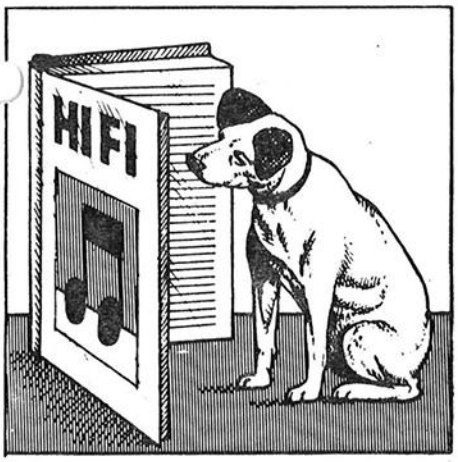
**Postscript: In December 1982 National Panasonic, the UK arm of Matsushita/Technics was fined £250,000 by the EEC Commission for practices contrary to the Treaty of Rome, specifically the clauses aimed at preserving free trade between EEC member states. The case related to a 1979 incident in which National Panasonic had refused to supply goods to retailers Lasky's, whose holding company, Audiotronics, had shipped its manufactured goods to French and Dutch shops. In a scenario more in keeping with the cinema than the hi-fi scene EEC officials seized documents in a dawn raid on Panasonic's Slough headquarters. It has taken up to the end of last year for the case to be decided.**

**Matsushita are not the only hi-fi conglomerate whose marketing practices have fallen foul of EEC rules. Pioneer were recently fined a similar amount, and European manufacturers Grundig, Saba, and Telefunken are also said to be under investigation currently. — Features Ed.**




# BOOKS

**BERLIOZ** by Hugh Macdonald. 261 pages, 7 half-tones, 4 line illustrtions, 62 musical examples, hard covers. Price £8.95. Published in 'The Master Musicians' series by *J. M. Dent & Sons Ltd,* 33 Welbeck Street, London W1M 8LX.

FOR OVER 40 years J. H. Elliot's somewhat unenthusiastic book on Berlioz has been the standard 'Master Musicians' volume, and it surprised many Berliozians that as late as 1967 this pre-war study was regarded as worthy of a further edition. Much has happened to public awareness of the composer and to appreciation of his music over these four decades, espcially since 1950, when, as noted at the conclusion of this new book, Jacques Barzun's huge propagandist biography appeared in coincidence with the birth of the LP record — which has brought much previously obscure music to millions of fresh ears.

We have a more relaxed setting for this long-needed replacement of the Elliot, in which Professor Macdonald devotes four chapters (75 pages) to a dignified summary of Berlioz's life and character, followed by five chapters (131 pages) dealing with his music and musical style. There are also Appendices giving a calendar of events, a comprehensive list of works (both surviving and lost), notes on key personalities, and a useful bibliography — which pointedly excludes Elliot! Plus of course an Index.

Prof. Macdonald is General Editor of the *New Berlioz Edition,* an eventually complete and totally authoritative version of all the composer's musical works, so he is probably the best equiped man on earth to produce a general overview of Berlioz's music. His amalgam of erudition and enthusiasm certainly comes over in the musical chapters, which follow a chronological scheme and manage to offer comments and/or analysis on *everything* in the way of compositions or arrangements that emanated from one of France's greatest composers. Being a musicologist, Prof. Macdonald follows a common assumption (or his publishers do) that lay readers will take printed musical quotations in their stride and hear the sounds in their head simply by studying the score. I happen to believe that this is wrong, and that the time is now ripe to issue a cassette of recorded examples with books such as this; but there are only 62 quotes here, and the text is so informative and interesting that I was constantly tempted to run off and find the relevant passages on recordings. I was also made to wish by various intriguing comments and descriptions that many rarely played and unrecorded works could be heard more easily: *Le cinq mai* or *Hymne a la France* for instance.

There are numerous passing phrases and ideas that give pause for thought, sometimes about music in general as much as about Berlioz in particular — as for instance at the end of a passage on the *Funeral & Triumphal Symphony:* 'mourning has always inspired finer music than triumph'. There is much sadness and quiet beauty in the music of Hector Berlioz, as well as much grandeur, and it is to Hugh Macdonald's great credit that he gives us a truly balanced and deeply informed assessment of it all in this fine study.

*John Crabbe*